DOUGLAS REPORT NO. SM-46703

DESIGN EVALUATION/QUALIFICATION TEST

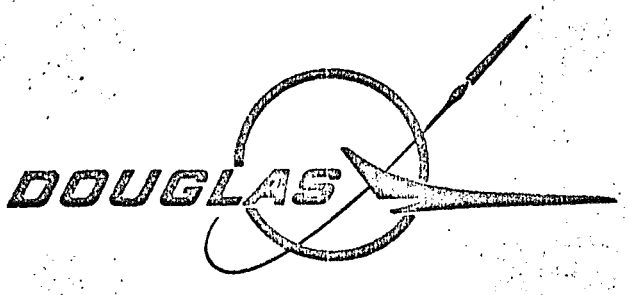
of

THERMOELECTRIC CALORIMETER TRANSDUCER

DOUGLAS SPECIFICATION CONTROL NUMBER

1A96572-501

Prepared by



ASTRIONICS BRANCH

OCTOBER 10, 1964

For

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NO. NAS7-1

MODEL NO. SATURN S-IV

Approved by:

A. W. Rebard
Chief, Astrionics Branch

ABSTRACT

This report was prepared by the Douglas Aircraft Company, Inc., to present the test procedures used for, and results of, qualification tests of the Thermoelectric Calorimeter Transducer, Douglas Specification Control No. (SCN) 1A96572-501. The transducer is manufactured by the Hy-Cal Engineering Company as P/N C-1161-A-03.

The transducer was subjected to acoustical noise, acceleration, random vibration, shock, and humidity environments to verify that it would operate within the specified requirements.

The information in this report, presented in the form of a test summary table, operational requirements, test procedures and results, and laboratory test data sheets, provides the data necessary for approval of the calorimeter transducer for use on the Saturn S-IV.

DESCRIPTORS

Saturn S-IV

Environmental Testing

Thermoelectric

Calorimeter

Heat

Flux

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1.0 INTRODUCTION

This report presents the procedures used for, and the results of, qualification tests of the thermoelectric calorimeter transducer, SCN 1A96572-501.

The transducer consists of a circular, black-coated heat sensing element of constantan metallurgically bonded to a threaded copper heat sink (figure 1). Two copper leads, one welded concentrically to the constantan sensing element and the other welded to the copper heat sink, are attached to connector pins. The millivolt dc output of the transducer, produced by the temperature differential between the two copper constantan thermocouple junctions, is proportional to the heating rate of the transducer. The transducer's maximum operating temperature is 200°F, and its full scale output requires a heating rate input of 3 BTU/ft^2-sec. The transducer's output provides telemetry data on the heating rate at the area of transducer installation.

Three transducers are mounted in the aft skirt near the aft interstage, between fin planes I and IV, with the sensing elements flush with the stage outer surface.(figure 2).

The tests performed on the transducer and the results of the tests are summarized in paragraph 2 and described in detail in paragraph 4. Laboratory data recorded during the tests are presented in the appendix. Operational requirements for the transducer are specified in paragraph 3 and any deviations from these requirements, or from the environmental test requirements noted in the test summary tables of paragraph 2, are explained in paragraph 5. Paragraph 6 states the conclusions drawn from the results of the tests.

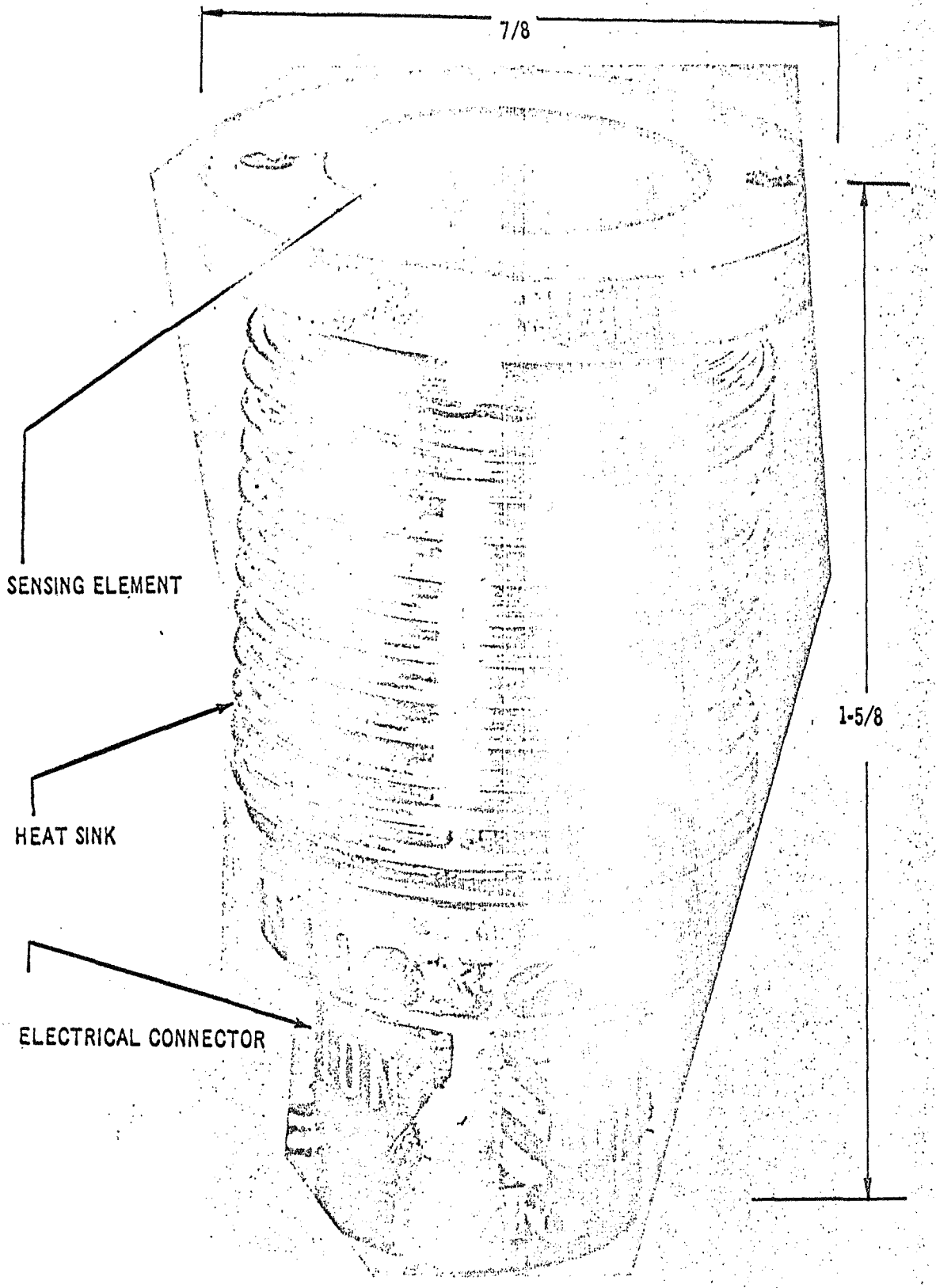


FIGURE 1 THERMOELECTRIC CALORIMETER TRANSDUCER DOUGLAS SCN 1A96572-501

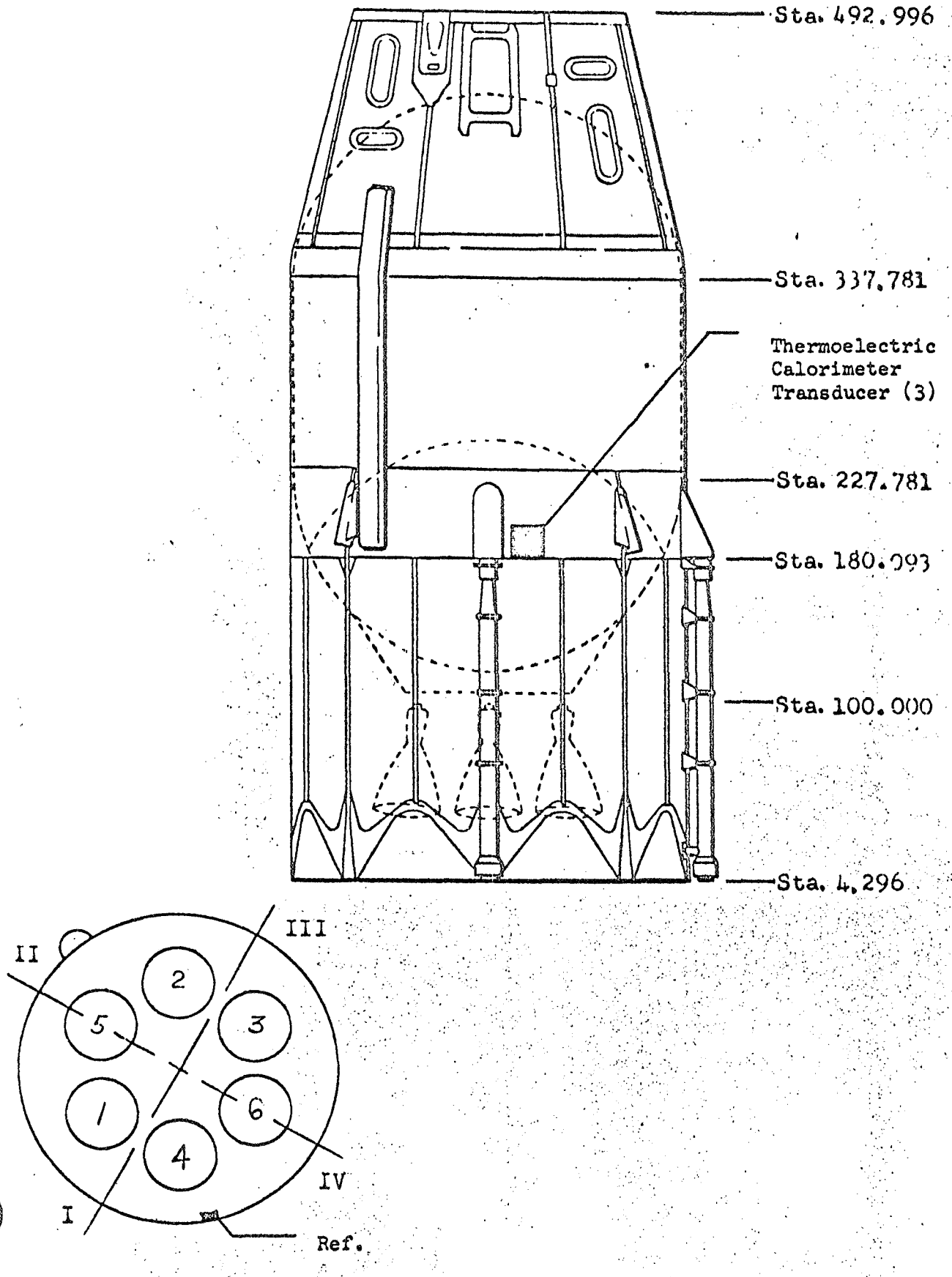


FIGURE 2. ITEM LOCATION SATURN S-IV

2. TEST SUMMARY TABLES

These tables provide a brief summary of the environmental test parameters and the results of operational tests performed to verify conformance with operational requirements.

Test Specimens:
Two (2) calorimeter transducers, SCN 1A96572-501, S/N's 11931 and 11936

ENVIRONMENTAL PARAMETERS		
REQUIRED	ACTUAL TEST	RESULTS/REMARKS
Acoustical Noise: S/N 11931 30 minutes random noise environment, 153.2 db overall spl in the 37.5 to 9600 cps frequency range. Test Tolerance: +1, -2 db each octave band.	Same as requirements, except for minor deviations noted in paragraph 4.4.1.	Satisfactory. See paragraphs 4.4.1 and 5; and pages SM-23, and SM-15 thru 17.
Acceleration S/N 11931 7g for 12 minutes in both directions of each axis.	Same as requirements	Satisfactory. See paragraph 4.4.2, and pages SM-17 and 18.
Random Vibration: S/N 11931 1-½ minutes in each axis at the following power spectral density, followed by 16 minutes in each axis at 3 db less: 20 - 30 cps 0.02 g^2/cps 30 - 100 cps +5 db/oct 100-800 cps 0.15 g^2/cps 800-2000 cps -5 db/oct Test tolerance: ± 3 db power	Same as requirements	Satisfactory. See paragraph 4.4.3 and pages SM-17 and 18, and SM-24 thru 38.

ENVIRONMENTAL PARAMETERS		
REQUIRED	ACTUAL TEST	RESULTS/REMARKS
Shock: S/N 11931 3 sawtooth shocks in each axis, 35 g 0-peak, 1 milli-second.	Same as requirements	Satisfactory. See paragraph 4.4.4, and pages SM-18 and 19, and SM-39 thru 41.
Humidity: S/N 11936 Ten 24-hour temperature cycles, 84 to 160 to 84°F, with 95% relative humidity. Test Tolerance: Low Temp: ± 16°F High Temp: ± 4°F Humidity: ± 5%	Same as requirements, except: post test made after 9th cycle, followed by 3 more cycles.	Satisfactory. See paragraph 4.4.5 and 5, and pages SM-8, and SM-20 thru 22.
Operational Heat Flux Exposure to 8 minutes at 200°F and heat flux of 3 BTU/ft^2-second	Same as requirements	Satisfactory. See paragraph 4.4.6 and pages SM-9 and 19, and SM-42 thru 49.

3. OPERATIONAL REQUIREMENTS

3.1 Transducer Output

The transducer output shall be 13.5 ± 1.5 millivolts for a calibrated heat flux input of 3 BTU/ft^2/second.

3.2 Continuity

The transducer resistance, measured between pins A and C, shall be less than 20 ohms.

4. TEST PROCEDURES AND RESULTS

4.1 Environmental Test Sequence

Two SCN 1A96572-501 Thermoelectric Calorimeter Transducers, S/N's 11931 and 11936, were subjected to environmental tests in the following sequence:

S/N 11931	S/N 11936
Acoustical Noise	Humidity
Acceleration	Operational Heat Flux
Random Vibration	
Sawtooth Shock	
Operational Heat Flux	

4.2 Pre- and Post-Test Procedure

Resistance and output of the transducer were measured and recorded before and after each environmental test, except that the pre-test was omitted if less than 48 hours had elapsed since the preceding post-test. The resistance between pins A and C was measured and recorded at ambient temperature before installing the transducer

4.2 Pre- and Post-Test Procedure (Continued)

in a heat flux box and exposing it to a calibration heat flux of 3 BTU/ft^2/second for 10 seconds. During this period, the transducer output was measured and recorded as a function of time, using an X-Y plotter. The heat flux procedure was repeated two to four times for each test. The transducer then was restabilized at ambient temperature and the resistance between pins A and C was measured again.

4.3 Test Specimen Mounting

Each transducer was mounted in a test fixture simulating a 19 x 25 - inch section of the aft skirt of the Saturn S-IV for all tests except the pre- and post-tests and the operational heat flux test. Identification of axes for applicable tests was as shown on pages SM-12 through 14.

4.4 Environmental Test Procedures and Results

4.4.1 Acoustical Noise Test

The transducer and test fixture were suspended with bungee cord in a 1000 cubic foot acoustical reverberation chamber (page SM-4) for the acoustical noise test. Three microphones suspended one foot from the transducer were used to monitor the acoustical levels. Continuity also was monitored during the test. The random noise spectrum was as follows:

4.4.1 Acoustical Noise Test (Continued)

Octave Band	Center Freq. (Cps)	Sound Pressure Level (db)
1	31.5	139
2	63	142
3	125	144
4	250	146
5	500	147
6	1K	147
7	2K	145
8	4K	143
9	8K	137

The overall sound pressure level was maintained at the above octave sound levels for 30 minutes.

The test produced no changes in the mechanical or electrical characteristics of the transducer. The pre- and post-test results are shown on pages SM-15 through 17. Page SM-23 is a graph of the arithmetic average of the three microphones test levels and the specification sound pressure levels.

4.4.2 Acceleration Test

The transducer and test fixture were subjected to an acceleration force of 7g for 12 minutes in both directions of each of three mutually perpendicular axes. The acceleration test was accomplished without any changes in the transducer's characteristics. The pre- and post-test results are shown on pages SM-17 and 18.

4.4.3 Random Vibration Test

The transducer and test fixture were subjected to 1.5 minutes of random vibration in each of three mutually perpendicular axes. The power spectral density program was within ±3 db of the following vibration profile.

20 - 30 cps	0.02 g^2/cps
30 - 100 cps	+5 db/octave
100 - 800 cps	0.15 g^2/cps
800 - 2000 cps	-5 db/octave

The transducer was subjected to an additional random vibration of 16 minutes in each of the three axes. The power spectral density program was 3 db less than that for the 1.5 minute program above.

The accelerometers were located on the assembly as shown on pages SM-12, 13, and 14. Continuity of the transducer was monitored and recorded using the setup shown on page SM-10. Photographs of test setup are on pages SM-5 and 6.

There were no electrical or mechanical failures experienced by the transducer. The pre- and post-test results are shown on pages SM-17 and 18. The power spectral densities experienced by the accelerometers mounted on the test fixture are shown on pages SM-24 through 38.

4.4.4 Mechanical Shock Test

The transducer and test fixture were subjected to nine sawtooth waveform shock pulses of 35g zero-to-peak amplitude and 1 millisecond duration. Each shock pulse was generated by the vibration equipment

4.4.4 Mechanical Shock Test (Continued)

...g a single sawtooth pulse from the sweep circuit of a oscilloscope as the control waveform.

The diagram of the shock test setup is shown on page SM-11. The transducer was shocked three times in one direction of each of three mutually perpendicular axes.

The shock test was completed without failure or damage to the transducer. Pre- and post-test results are shown on pages SM-18 and 19. Photographs of the shock pulses in each axis are shown on pages SM-39 through 41.

4.4.5 Humidity Test

The transducer and test fixtures were placed in a humidity chamber (...age SM-79), stabilized at 84° ± 16°F and the relative humidity maintained at 95% ± 5%. The temperature was gradually increased for 2 hours to 160 ± 4°F and held at this temperature for 6 hours. The temperature was then decreased for 16 hours to 84°F. This 24 hour period constituted one cycle. After each cycle the resistance between pins A and C was measured, the data recorded are shown on page SM-21. After the 9th cycle, the humidity post-test was performed and the transducer was again placed in the chamber for three more cycles. Following the final three cycles a second post-test was performed. The results of the pre-test and both post-tests are shown on pages SM-20 through 22.

There were no appreciable changes in the continuity of the transducer resulting from the humidity test; all readings were well within tolerance.

4.4.5 Humidity Test (Continued)

The outer surface of the heat sink was darkened slightly by a corrosive coating and the sensing element surface showed some change from the humidity environment.

Figure 1 shows the element before humidity exposures, the photograph on page SM-8 shows the element after exposure.

When the transducer was removed from the humidity environment and subjected to post-test calibration heat flux, the transducer output was approximately 0.55 millivolts more than the pre-test value, but still within tolerance. Successive exposure to the heat flux environment resulted in the output returning to the pre-humidity value, as indicated by the previously referenced pre- and post-test data pages.

4.4.6 Operational Heat Flux Test

The two transducers were exposed to a heat flux of 3 BTU/ft^2/second for 8 minutes. The output of each transducer was recorded, and the temperature of each transducer heat sink was also measured and recorded, using the output of a chromel-alumel thermocouple adjacent to the heat sink. Data recorded are shown on pages SM-42 through 49. After 2 minutes of operation, a jet of air was used to prevent the heat sink from overheating.

During the test, the output of transducer S/N 11931 decreased 0.7 millivolts from the initial value after exposure to heat flux for 2 minutes. After 8 minutes of heat exposure, the output was 3.1 millivolts less than the initial value.

4.4.6 Operational Heat Flux Test (Continued)

output of transducer S/N 11936 decreased 1.2 millivolts after 2 minutes of heat flux exposure. The output decreased 3.7 millivolts from its initial value after 8 minutes of heat exposure.

The heat sink body temperature of both transducers increased almost lineally for the first 2 minutes of heat exposure, then became almost constant after air was applied to the body (pages SM-87, SM-88, SM-90, SM-91, SM-92, and SM-94).

During the test the original black coating disappeared from the central area of the sensing element surface of both transducers, exposing the constantan, as shown in the photograph of S/N 11931 on page SM-9.

5. DISCUSSION

5.1 Acoustical Noise

The specified tolerances for the acoustical noise test (paragraph 4.4.1) were +1, -2 db for each octave band. The controllable range of the equipment conformed to the tolerances in the 63 to 1000 cps bands only; however, the overall sound pressure level was considered satisfactory for the remaining bands.

5.2 Humidity

Deviation from the specified ten 24-hour-cycle humidity test was necessitated by test scheduling; the nine and three 24-hour-cycle tests (paragraph 4.4.5) were considered adequate to fulfill requirements.

5.2 Humidity (Continued)

Deterioration of the sensing element surfaces did not affect performance of the specimens; all specified operational requirements were fulfilled during and after the humidity test. However, analysis of the crystalline deposits on the sensing element surfaces were performed. The constantan sensing elements, composed of 40 percent nickel and 60 percent copper, had yielded nickel copper oxide (Ni Cu O_2) and nickel oxide (NiO) in the moisture laden air.

5.3 Operational Heat Flux

During the post test (paragraph 4.4.6) over-heating caused deterioration of the black coating on the sensing element surfaces resulting in an out-of-tolerance condition for both specimens. Since the over-heating was caused by an abnormal test environment not simulating the actual in-flight environment, Douglas engineering considers that the specimens did meet requirements and that the out-of-tolerance condition should be disregarded.

6. CONCLUSION

Based on the qualification test results presented in this report, it is the conclusion of the Douglas Aircraft Company, Inc., that the Thermoelectric Calorimeter Transducer, Douglas SCN 1A96572-501, will perform the intended function on the Saturn S-IV stage.

APPENDIX

TEST EQUIPMENT

Tests were performed using the following equipment.

All Data acquisition equipment is certified per requirements specified in Military Specification MIL-C-45662A and NASA Quality Publication NPC 200-2.

Description	Manufacturer	Model/Type	S/N, T/N
Accelerator	Rucker	RCT-2	*1480
Charge Amplifier	Endevco	2628	HA16
Charge Amplifier	Endevco	2628	HA17
Power Amplifier	Ling	CP3/4	*611924-58
Heat Flux Black Box	Douglas	--	--
Wheatstone Bridge	Leads & Northrup	5305	1529181
Sound Level Calibrator	General Radio	1552-B	*8689
Camera	Fairchild	F-296	59-720
Humidity Chamber	Conrad	FD-64-0-3	7194
Humidity Chamber	Inreco	10108	389-2
Vibration Equipment	MB	C-10	479
Random Noise Equalizer/Generator	Allison	349	*611924-56
Transistor Oscillator	General Radio	1307-A	*626474
Oscillograph	CEC	5-124	4081
Oscillograph	Offner Electric	RGD	9
Oscilloscope	Tektronix	535A	021957
Oscilloscope	Tektronix	535A	022044
X-Y Plotter	Autograph	3	1271

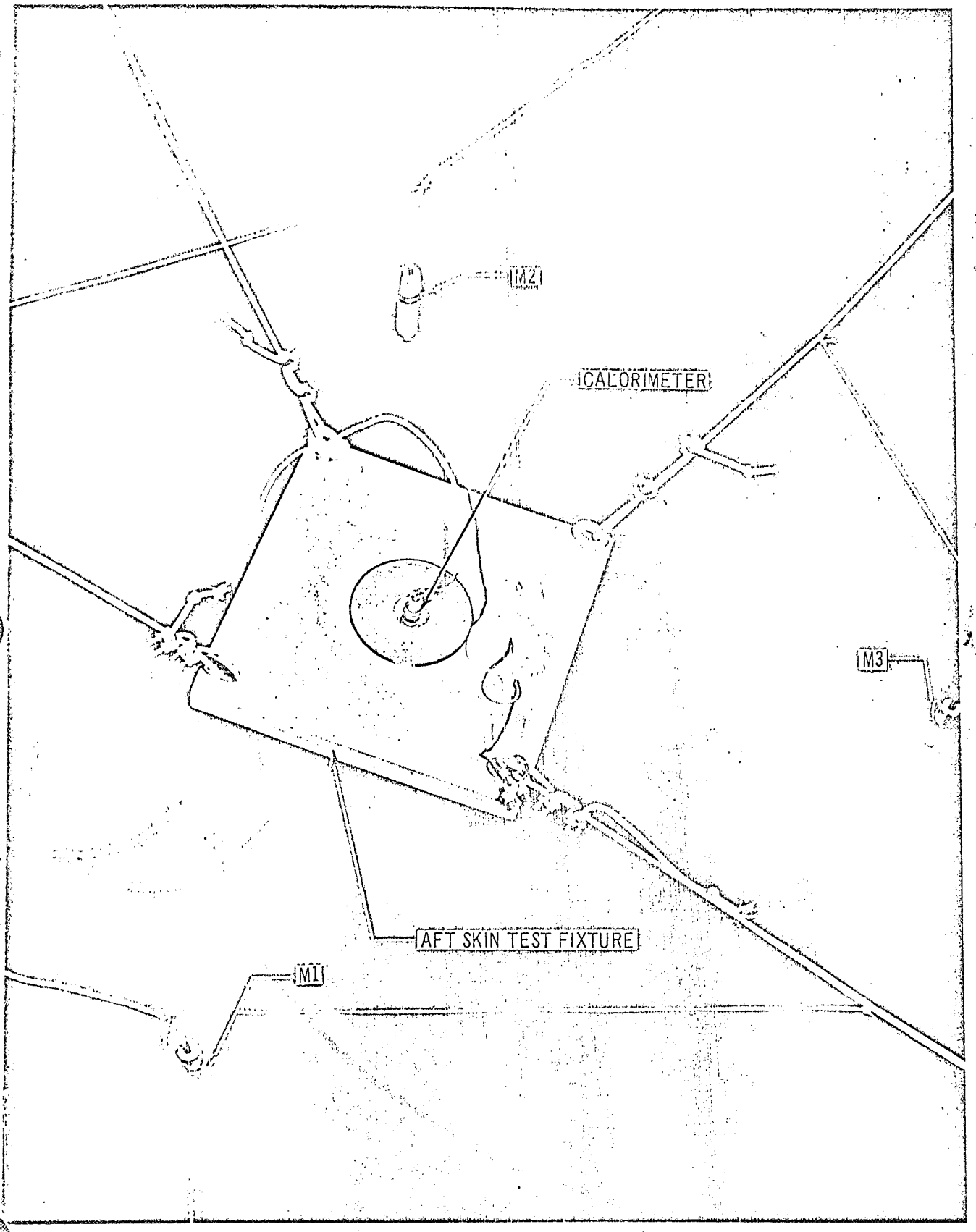
ST EQUIPMENT (Continued)

Description	Manufacturer	Model/Type	S/N, T/N
Millivolt Potentiometer	Leeds & Northrup	126W3	59002125002
Microphone Pwr. Supply (3)	Altec	527B	*611924-6(M1)
			-5(M2)
			-4(M3)
Level Recorder (Chart)	Bruel & Kjaer	2305	*611924-50
Tape Recorder	Precision Instr.	PS-207A	460
Temperature Recorder	Minn-Honeywell	Y156A15B-Wy-(L)	803220
Millivolt Source	Brown Instruments	--	P743B
Audio Freq. Spectrometer	Bruel & Kjaer	2142	*611924-49
True RMS Electronic Voltmeter	Bruel & Kjaer	2409R	*611924-51
Accelerometer(6)	Endevco	2226	HB52
			HB67
			HB81
			HB88
			HC14
			HC25
Galvanometer(9)	CEC	7-317	6334
			6916
			8472
			8818
			9186
			9787
			11529
		7-342	11519
			11534

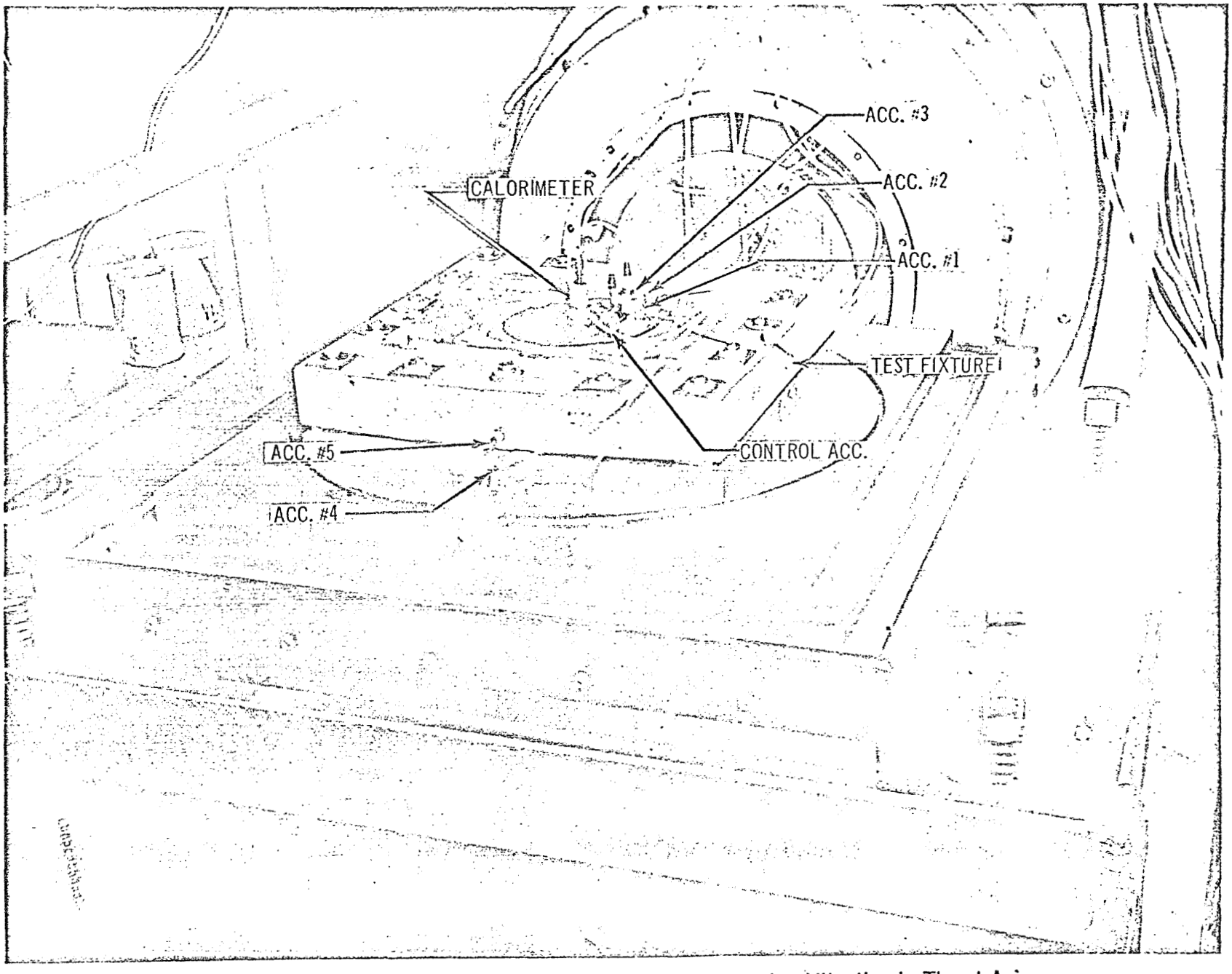
TEST EQUIPMENT (Continued)

Description	Manufacturer	Model/Type	S/N, T/N
Condenser Microphone(3)	Altec	21BR-180	8173(M1)
			9128(M2)
			9782(M3)
Electropneumatic Transducer(10)	LTV	6786	--

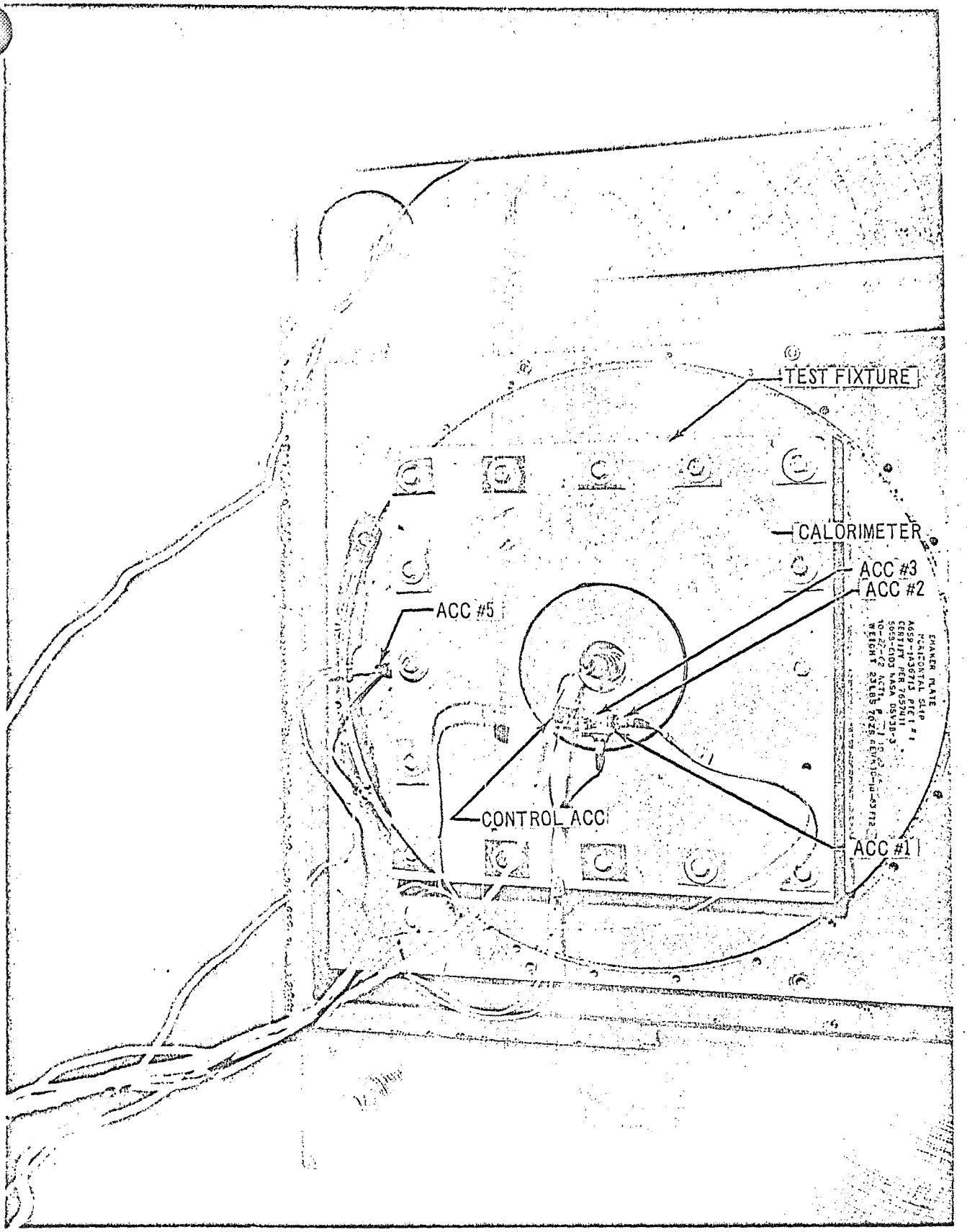
Note: *(DAC Tag Number)



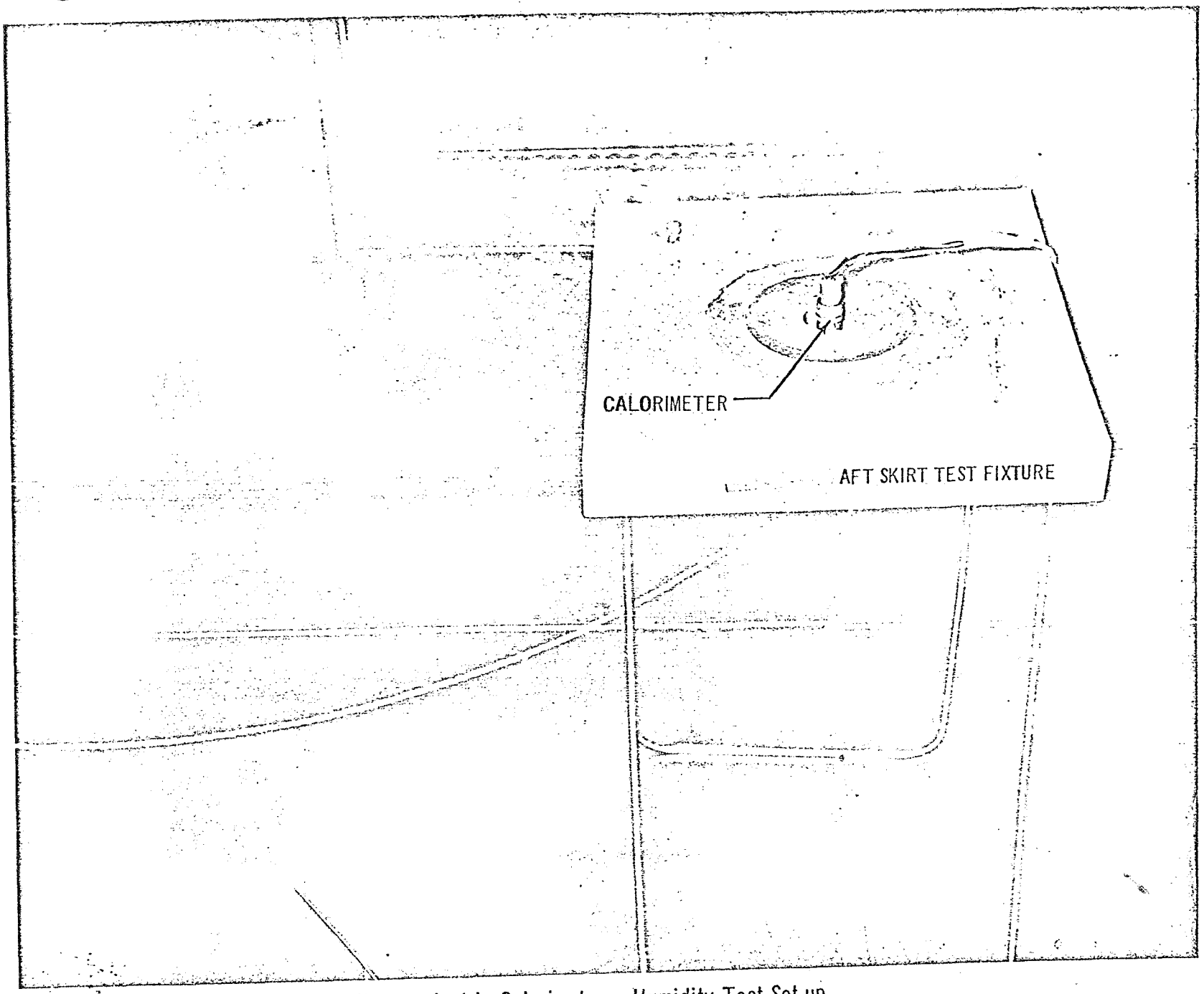
Thermoelectric Calorimeter Acoustical Noise Test



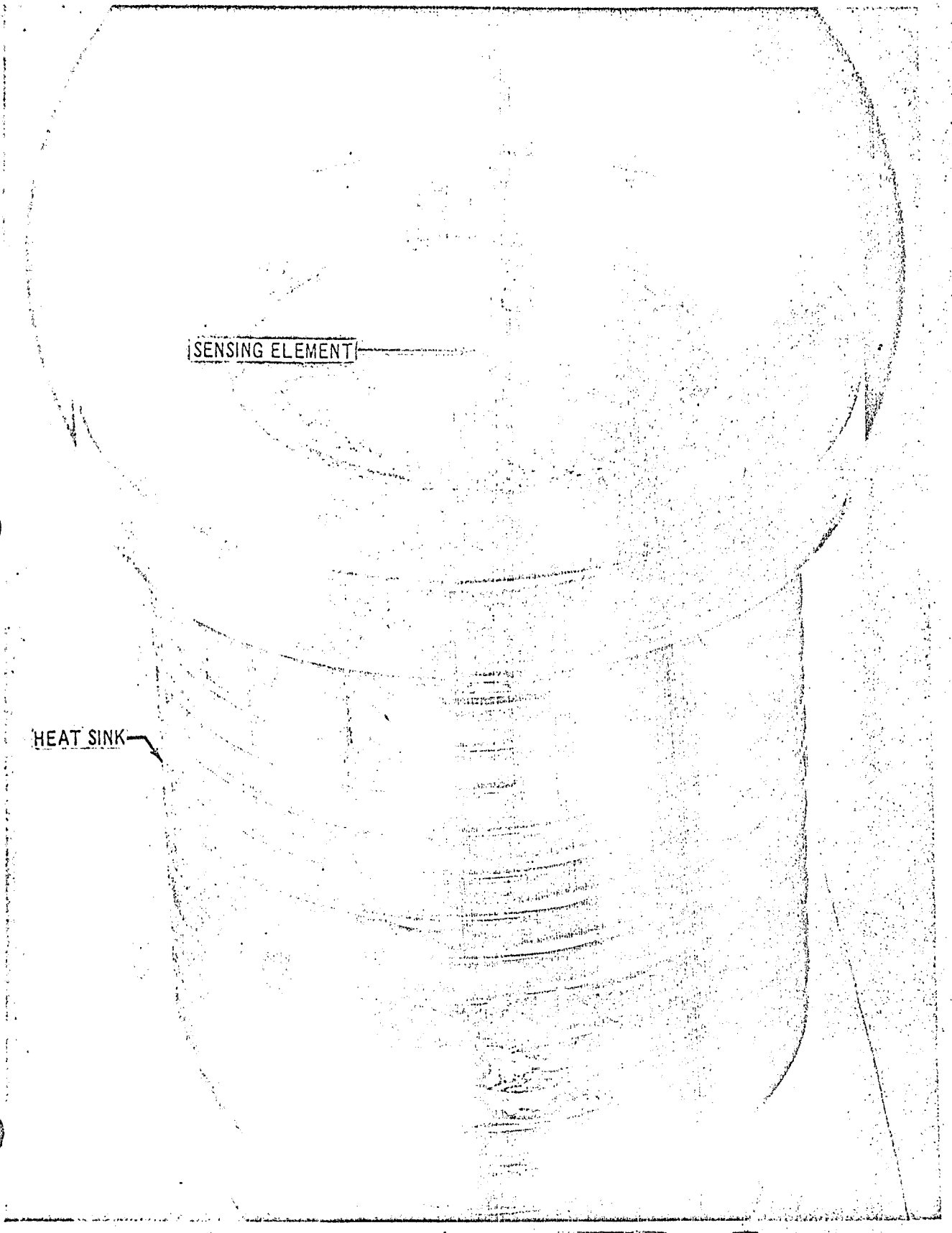
Thermoelectric Calorimeter – Vibration Test Set-up Random Vibration in Thrust Axis



Thermoelectric Calorimeter – Vibration Test Set-up Random Vibration in Thrust Axis



Thermoelectric Calorimeter – Humidity Test Set-up



Thermoelectric Calorimeter – Calorimeter After Humidity

FORM 25-9-1 (REV. 9-55)

PREPARED BY: R. Stoltz

CHECKED BY:

DATE: 6/12/64

DOUGLAS AIRCRAFT COMPANY, INC.

MISSILE AND SPACE SYSTEMS DIVISION

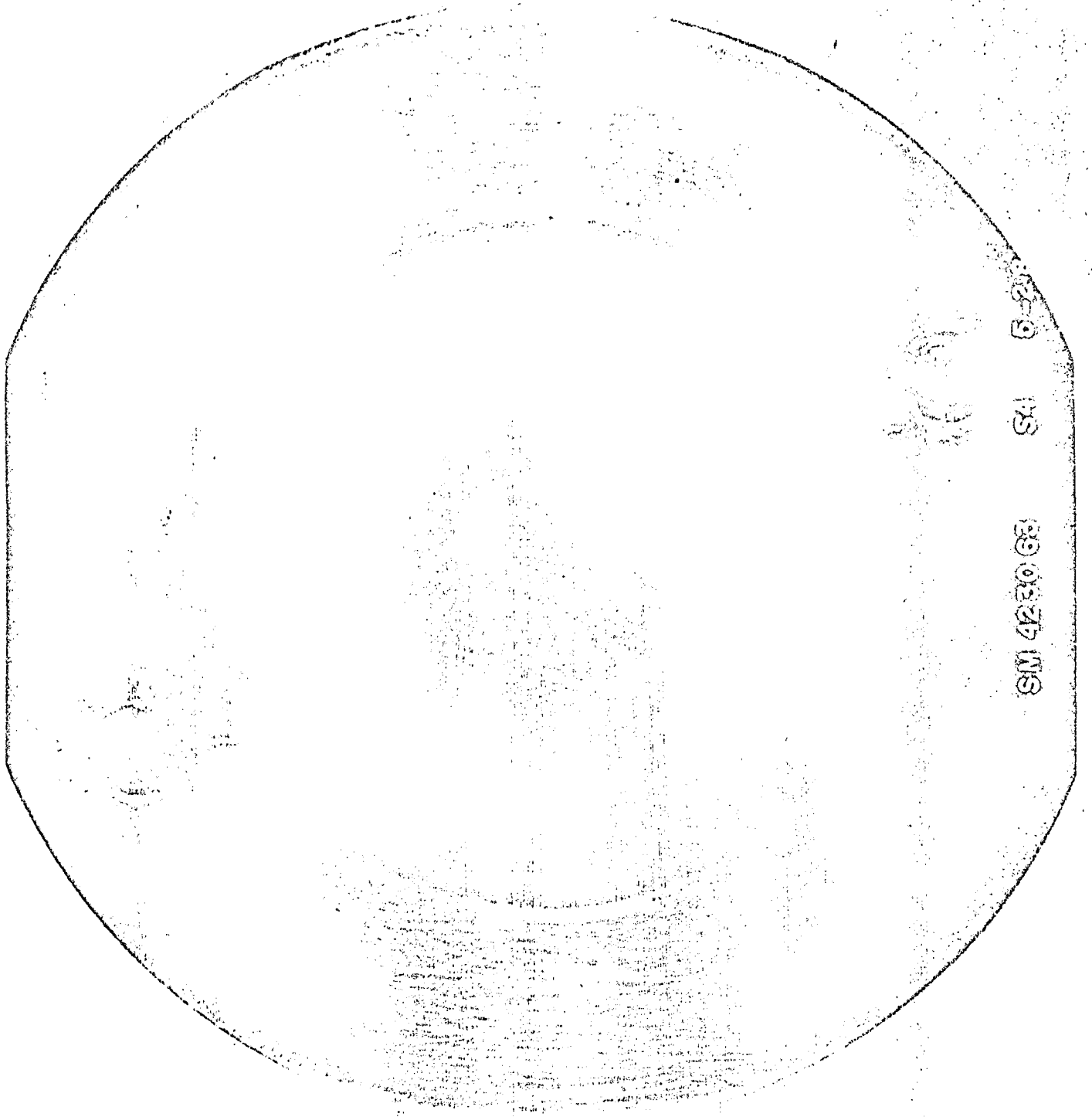
MODEL: DSV - 4

TITLE: THERMOELECTRIC CALORIMETER - SENSING ELEMENT AFTER OPERATIONAL PERIOD TEST

REPORT NO: TM-R-4520

P/N 1A96572-501 S/N 11931

ADD. # 1



SM-10

M 23-8-1
V. 8-531

PREPARED BY: R. Stoltz

CHECKED BY:

DATE: 1-/..

DOUGLAS AIRCRAFT COMPANY, INC.

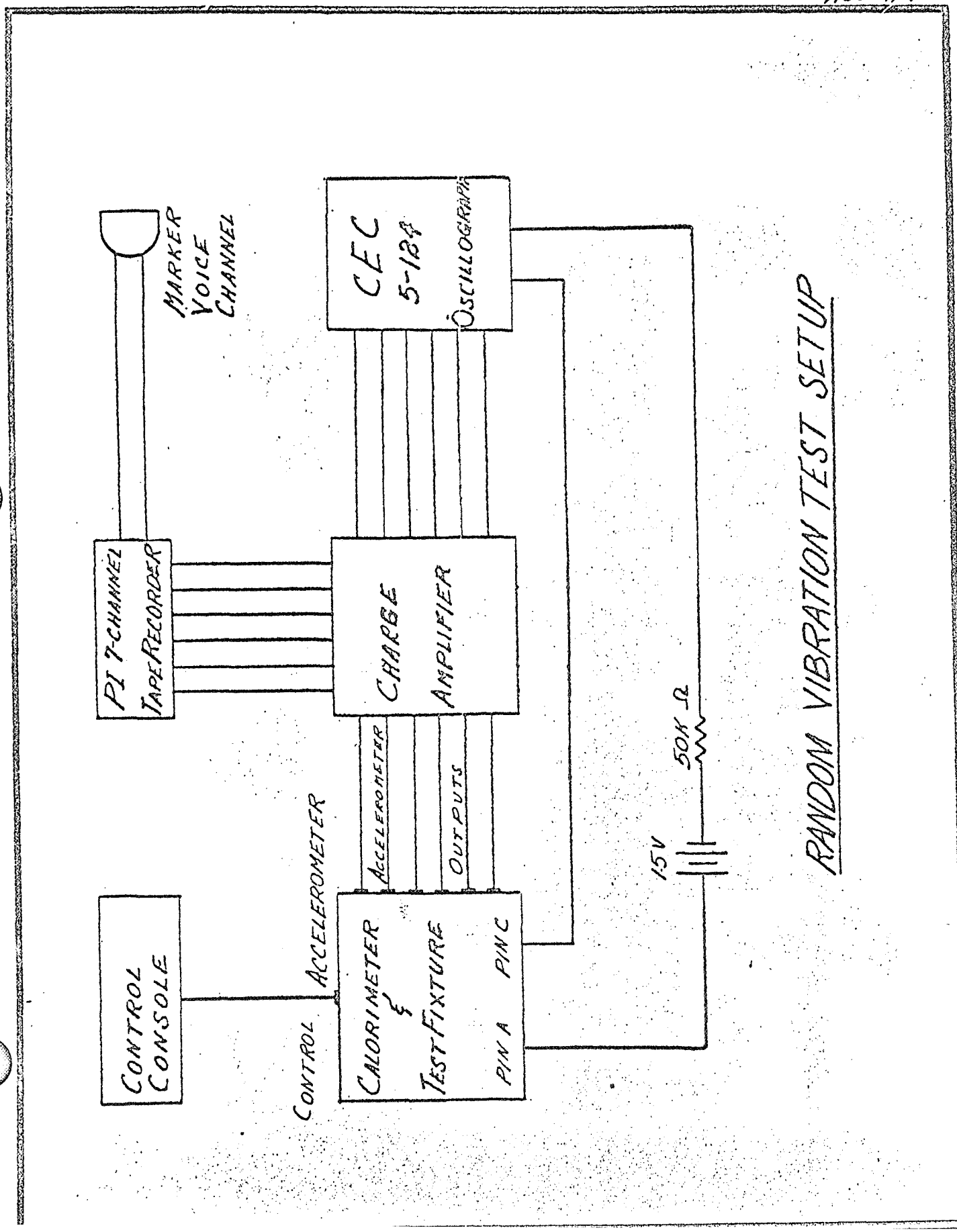
MISSILE AND SPACE SYSTEMS DIVISION

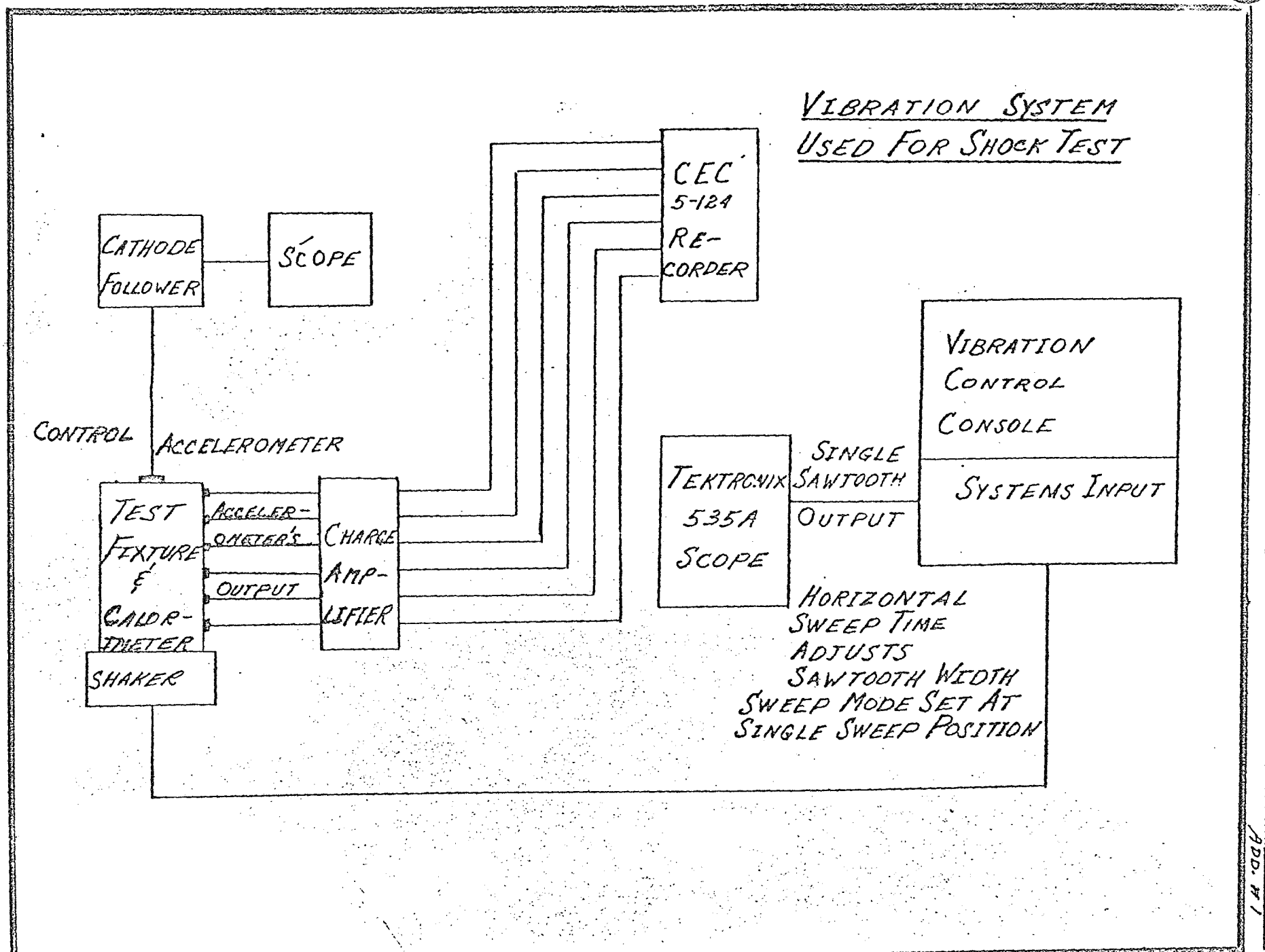
PAGE: A-1

MODEL: DSV - 4

TITLE: THERMOELECTRIC CALORIMETER Random Vibration Test Set Up

REPORT NO.: TM-R-4520 ADD. #1





PREPARED BY: R. Stoltz
CHECKED BY:
DATE:
TITLE: THERMOELECTRIC CALORIMETER Shock Test Set Up

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE & SPACE SYSTEMS DIVISION

PAGE: A-3
MODEL: DSV4-101
REPORT NO.: ZM-E-452 0 ADD. #1

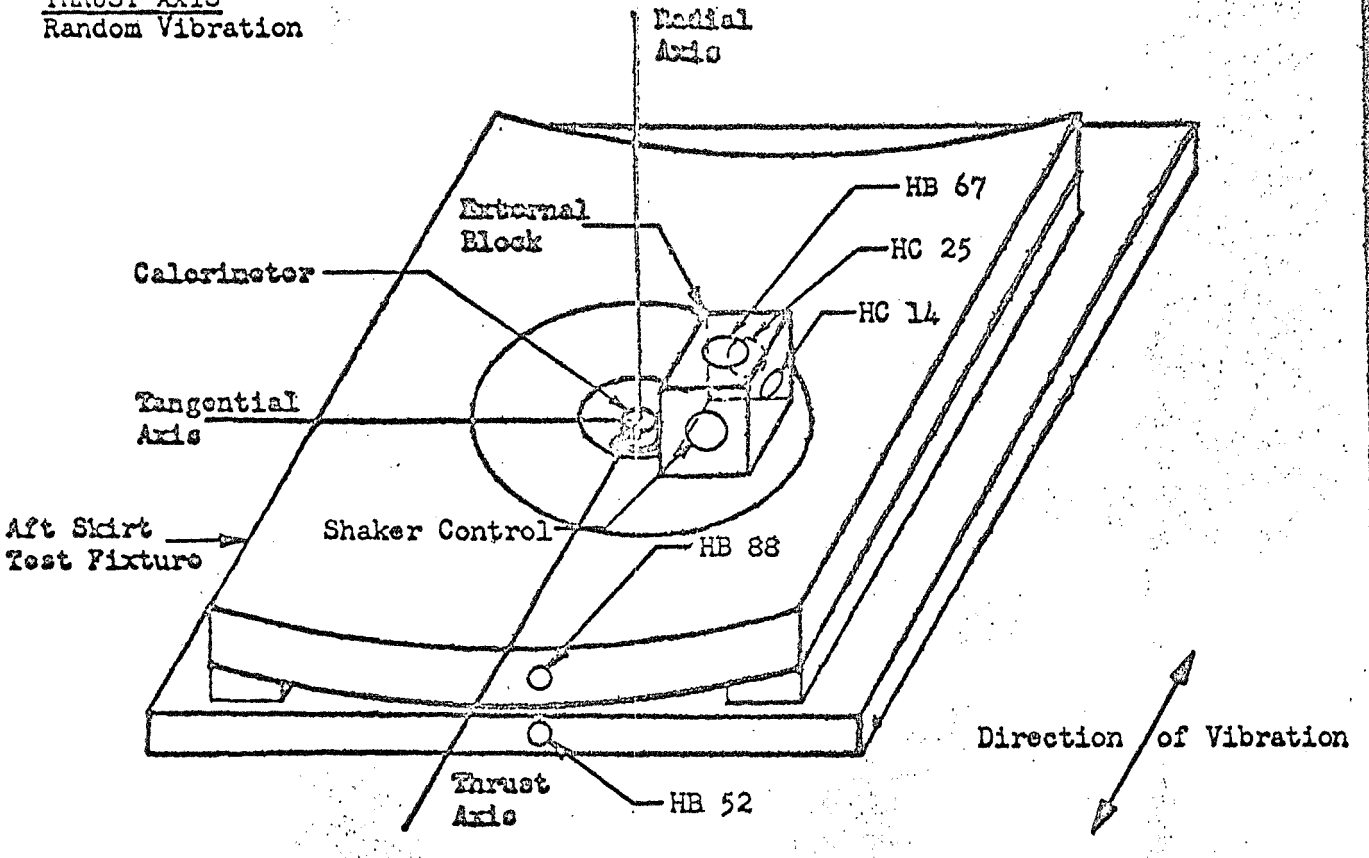
PREPARED BY R. Stoltz
CHECKED BY
DATE: 6/4/64

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE AND SPACE SYSTEMS DIVISION

TITLE: THERMOELECTRIC CALORIMETER Accelerometer Locations

REPORT NO.: TM-K-4520 ADD. No. 1

THRUST AXIS
Random Vibration



Accelerometer	Location of Accelerometer's Sensitive Axis	Accelerometer's Location on Assembly
No. 1 HC 14	Tangential Axis	External Block
No. 2 HC 25	Thrust Axis	External Block
No. 3 HB 67	Radial Axis	External Block
No. 4 HB 52	Thrust Axis	Mounting Plate
No. 5 HB 88	Thrust Axis	Test Fixture
Control	Thrust Axis	External Block

Note: Control accelerometer's output was not recorded. The control profile is given by accelerometer No. 2.

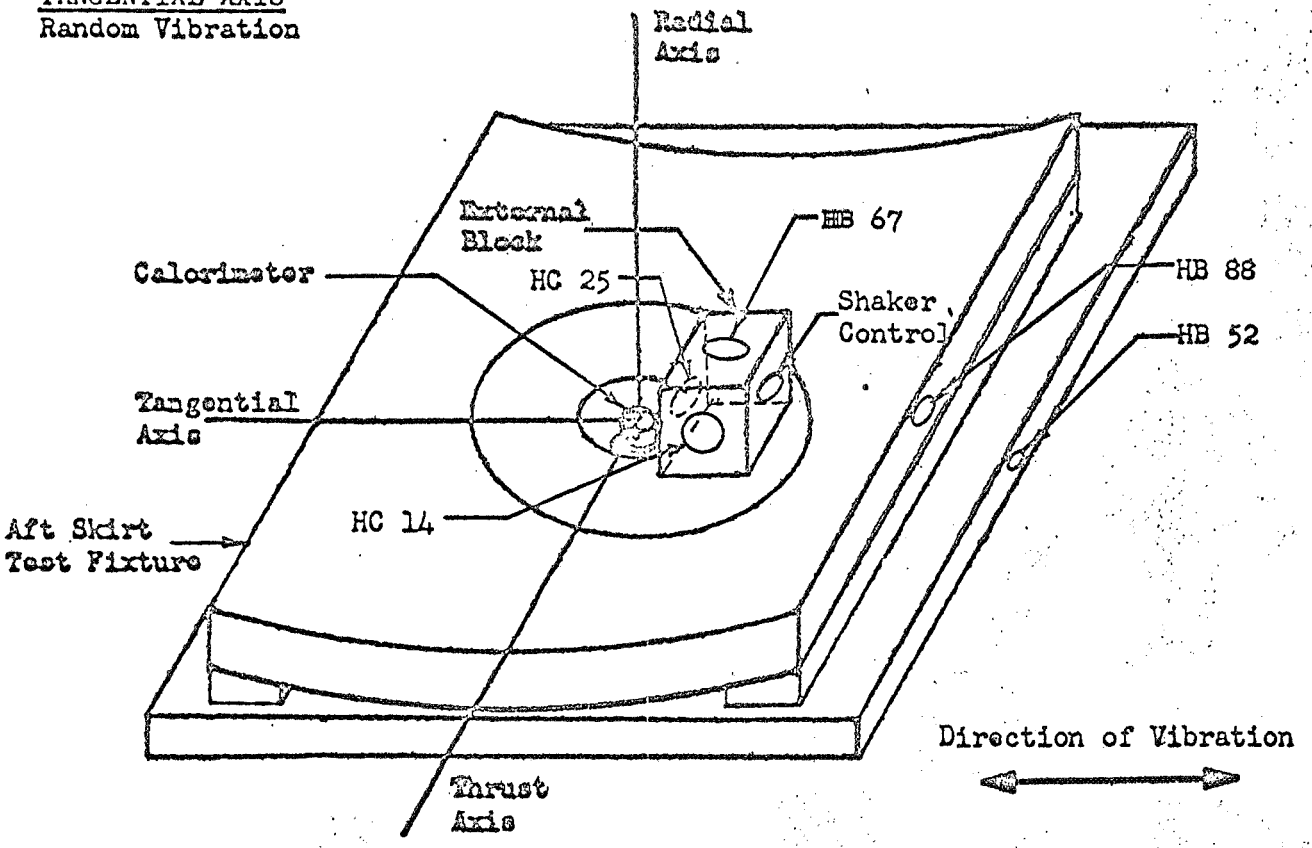
PREPARED BY R. Stoltz
CHECKED BY
DATE: 6/4/64

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE AND SPACE SYSTEMS DIVISION

TITLE: THERMOELECTRIC CALORIMETER Accelerometer Locations

REPORT NO.: TM-R-4520 ADD. #1

TANGENTIAL AXIS
Random Vibration



Accelerometer	Location of Accelerometer's Sensitive Axis	Accelerometer's Location on Assembly
No. 1 HC 14	Thrust Axis	External Block
No. 2 HC 25	Tangential Axis	External Block
No. 3 HB 67	Radial Axis	External Block
No. 4 HB 52	Tangential Axis	Mounting Plate
No. 5 HB 88	Tangential Axis	Test Fixture
Control	Tangential Axis	External Block

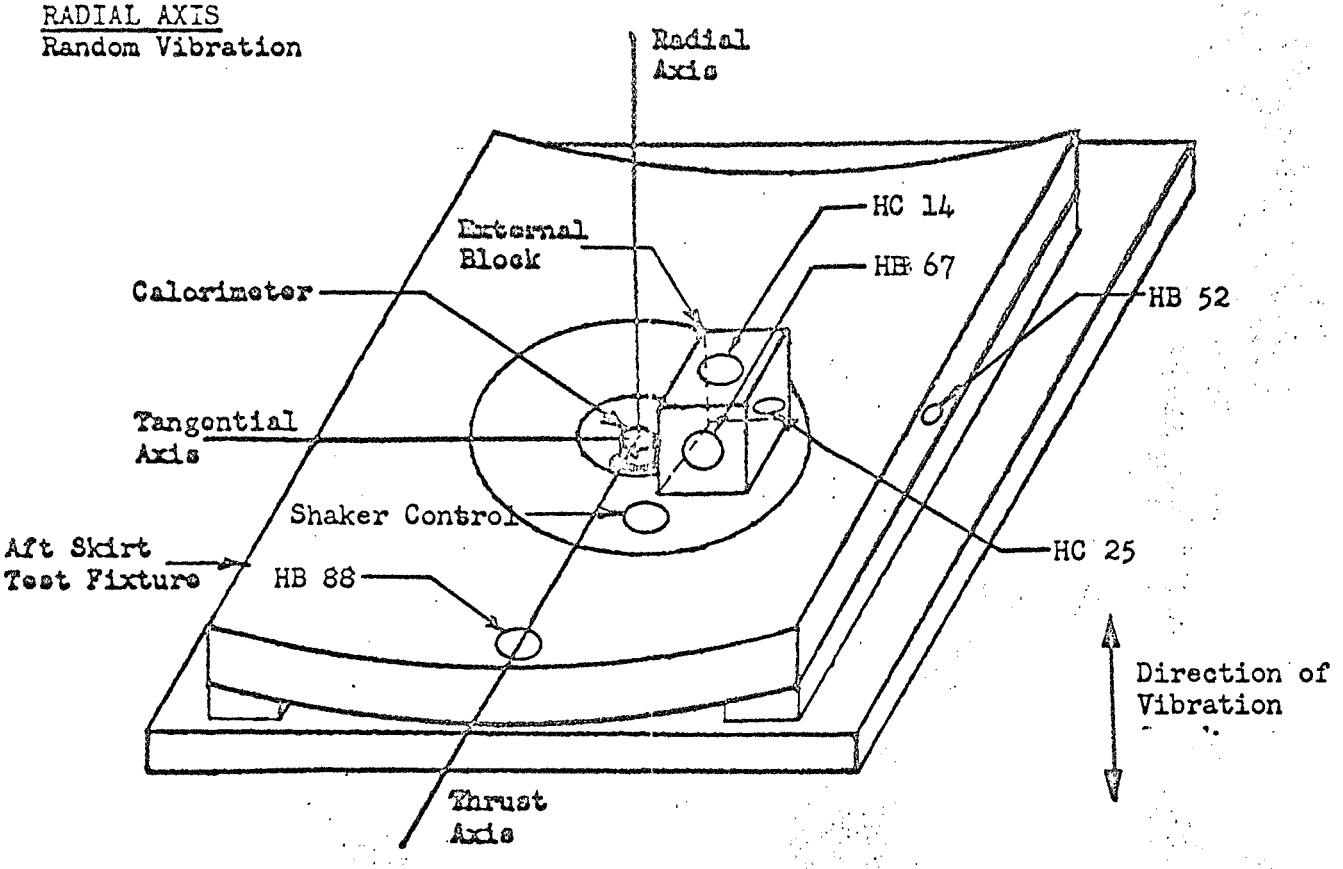
Note: The output of the control accelerometer was not recorded. The control profile is given by accelerometer No. 2.

PREPARED BY R. Stoltz
CHECKED BY
DATE: 6/4/64
TITLE: THERMOELECTRIC CALORIMETER Accelerometer Locations

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE AND SPACE SYSTEMS DIVISION

MODEL DSV-4
REPORT NO. TM-R-4520 ADD. #1

RADIAL AXIS
Random Vibration



Accelerometer	Location of Accelerometer's Sensitive Axis	Accelerometer's Location on Assembly
No. 1 HC 14	Radial Axis	External Block
No. 2 HC 25	Tangential Axis	External Block
No. 3 HB 67	Thrust Axis	External Block
No. 4 HB 52	Tangential Axis	Test Fixture
No. 5 HB 88	Radial Axis	Test Fixture Mounting Bolt
Control	Radial Axis	Next to Calorimeter on Test Fixture

Note: Control Accelerometer's output not recorded. Control profile is given by accelerometer #1.

MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.

SM-15

DATE 6-5-64 PRE & POST ENVIRONMENTAL TEST PAGE A-10

SUBJECT Thermocelectric Calorimeter TM-R-4520 ADD.1

TEST NO. _____ S.O. 5419-6011 D.W.O. 24475 D.R.O. 0251 MODEL NO. DSV-4

OBJECT OF THIS DATA Part Number 1A96572-501

OBSERVER _____ LABORATORY A-275 E/E-NGC ENGINEER R. E. Stoltz

Acoustical Noise Pre-Environmental Test (S/N 11931)

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.542
Lead Resistance	.135
Calorimeter Resistance	.407

Acoustical Noise Pre-Environmental Test (Cont'd)

Calibration Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	13.74
Run No. 2	2.98	13.68
Run No. 3	3.00	13.60
Run No. 4	3.00	13.68

Resistance:
(After 1st and Before 2nd Heat Flux)

	Ohms
Total Resistance	.523
Lead Resistance	.125
Calorimeter Resistance	.398

Calibration Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.99	13.65
Run No. 2	2.99	13.60

Second Calibration Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.98	13.60
Run No. 2	2.99	13.58
Run No. 3	2.99	13.50
Run No. 4	2.99	13.50

Resistance:
(After Heat Flux)

	Ohms
Total Resistance	.890
Lead Resistance	.480
Calorimeter Resistance	.410

Acoustical Noise Post Environmental Test (S/N 11931)

Acceleration Pre-Environmental Test

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.885
Lead Resistance	.480
Calorimeter Resistance	.405

Calibration
Heat Flux:

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.98	13.59
Run No. 2	2.99	13.60
Run No. 3	2.99	13.55

Resistance:
(After Heat Flux)

	Ohms
Total Resistance	.890
Lead Resistance	.480
Calorimeter Resistance	.405

Acceleration Post Environmental Test (S/N 11931)

Random Vibration Pre-Environmental

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.895
Lead Resistance	.480
Calorimeter Resistance	.415

Calibration
Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.99	13.64
Run No. 2	2.99	13.64
Run No. 3	2.99	13.61

Acceleration Post Environmental Test (Cont'd)

Random Vibration Pre-Environmental Test (Cont'd)

Resistance:
(After Heat Flux)

	Ohms
Total Resistance	.895
Lead Resistance	.480
Calorimeter Resistance	.415

Random Vibration Post Environmental Test (S/N 11931)

Mechanical Shock Pre-Environmental Test

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.895
Lead Resistance	.480
Calorimeter Resistance	.415

Calibration Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	13.57
Run No. 2	3.00	13.57
Run No. 3	3.00	13.60

Resistance
(After Heat Flux)

	Ohms
Total Resistance	.995
Lead Resistance	.480
Calorimeter Resistance	.415

Mechanical Shock Post Environmental Test (S/N 11931)

Operational Period Pre-Environmental Test

Resistance
(Before Heat Flux)

	Ohms
Total Resistance	.900
Lead Resistance	.400
Calorimeter Resistance	.500

Mechanical Shock Post Environmental Test (Cont'd)

Operational Period Pre-Environmental Test (Cont'd)

Calibration Heat Flux	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	13.65
Run No. 2	3.00	13.60
Run No. 3	3.00	13.55

Resistance (After Heat Flux)	Ohms
Total Resistance	.900
Lead Resistance	.400
Calorimeter Resistance	.500

Operational Period Post Environmental Test (S/N 11931)

Resistance (Before Heat Flux)	Ohms
Total Resistance	.900
Lead Resistance	.400
Calorimeter Resistance	.500

Calibration Heat Flux	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	10.68
Run No. 2	3.00	10.70

Resistance: (After Heat Flux)	Ohms
Total Resistance	.735
Lead Resistance	.148
Calorimeter Resistance	.587

Note: The variations which occur in the lead resistance are due to the use of different leads.

ATA SHEET

MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.

[SM-20]

DATE 6-5-64 PRE & POST ENVIRONMENTAL TEST PAGE A-9

SUBJECT Thermoelectric Calorimeter TM-R-4520 Addl.

TEST NO. _____ S.O. 5419-6011 D.W.O. 24475 D.R.O. 0251 MODEL NO. DSV-4

OBJECT OF THIS DATA Part Number 1A95672-501

OBSERVER _____ LABORATORY A-275 E/E-NGC ENGINEER R. E. Stoltz

Humidity Pre-Environmental Test (S/N 11936)

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.551
Lead Resistance	.135
Calorimeter Resistance	.416

Calibration:
Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.98	13.77
Run No. 2	2.98	13.60
Run No. 3	2.98	13.68

Resistance:
(After 1st Calibration and before 2nd Calibration Heat Flux)

	Ohms
Total Resistance	.531
Lead Resistance	.125
Calorimeter Resistance	.406

Calibration:
Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.98	13.57
Run No. 2	2.99	13.51
Run No. 3	2.98	13.50

Second Calibration
Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	2.99	13.50
Run No. 2	2.99	13.40
Run No. 3	2.98	13.39

Resistance:
(After Heat Flux)

	Ohms
Total Resistance	.904
Lead Resistance	.480
Calorimeter Resistance	.424

ATA SHEET

MISSILE & SPACE SYSTEMS DIVISION
DOUGLAS AIRCRAFT COMPANY, INC.

SM-21

DATE 6-5-64 HUMIDITY TEST PAGE A-87

SUBJECT Thermoelectric Calorimeter TM-R-4520 Add.)

TEST NO. _____ S.O. 5419-6011 D.W.O. 24475 D.R.O. 0251 MODEL NO. DSV-4

OBJECT OF THIS DATA Part Number 1A96572-501 S/N 11936

OBSERVER _____ LABORATORY A-275 E/E-NGC ENGINEER R. E. Stoltz

Measurements After Each Humidity Cycle

Date	Time	Calorimeter Resistance (Ohms)
5-19-64	11:45 AM	0.424
5-20-64	10:00 AM	0.435
5-21-64	10:30 AM	0.435
5-22-64	10:30 AM	0.435
5-23-64	11:00 AM	0.435
5-24-64	10:30 AM	0.435
5-25-64	11:05 AM	0.435
5-26-64	11:00 AM	0.465
5-27-64	10:30 AM	0.455
5-28-64	10:30 AM	0.415
6-1-64	2:30	0.415

Humidity Post Environmental Test

Resistance:
(Before Heat Flux)

	Ohms
Total Resistance	.895
Lead Resistance	.480
Calorimeter Resistance	.415

Calibration Heat Flux

	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	14.15
Run No. 2	3.00	14.10
Run No. 3	3.00	13.70

Humidity Post Environmental Test (Cont'd)

Second Calibration Heat Flux	Heat Flux (BTU/Ft^2-Sec.)	Steady State Output (Millivolts)
Run No. 1	3.00	14.10
Run No. 2	3.00	13.97
Run No. 3	3.00	13.65
Run No. 4	3.00	13.65

Resistance: (After Heat Flux)	Ohms
Total Resistance	.560
Lead Resistance	.148
Calorimeter Resistance	.412

Note: The variations in the lead resistance are due to the use of different sets of leads.

SM-23

A-85
TM-R-4520 ADD.1

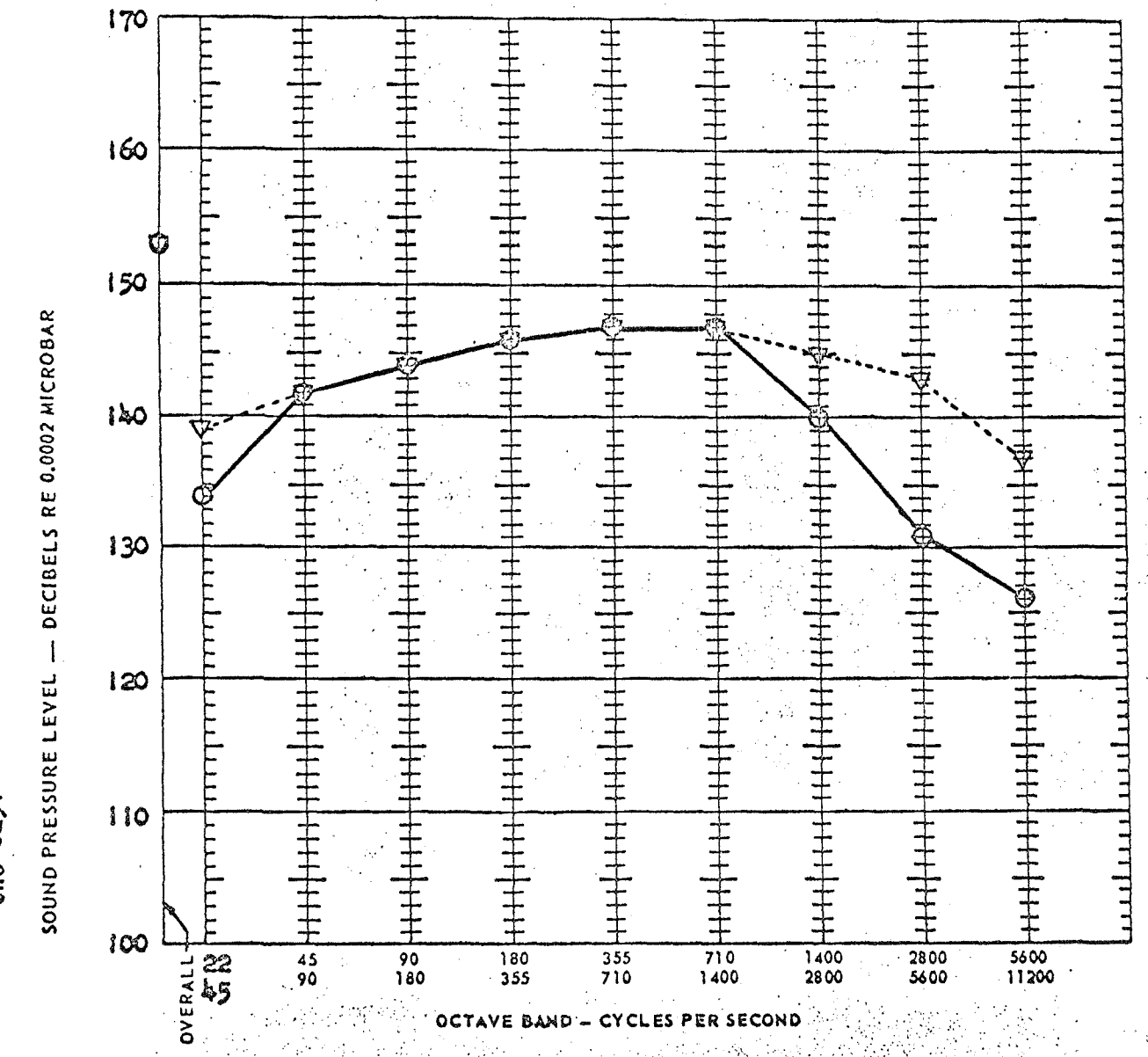
DOUGLAS

DE/Q ACOUSTIC NOISE TEST
TEST SPECIMEN: P/N 1A96572-901

DATE 5/19/64

PREPARED BY

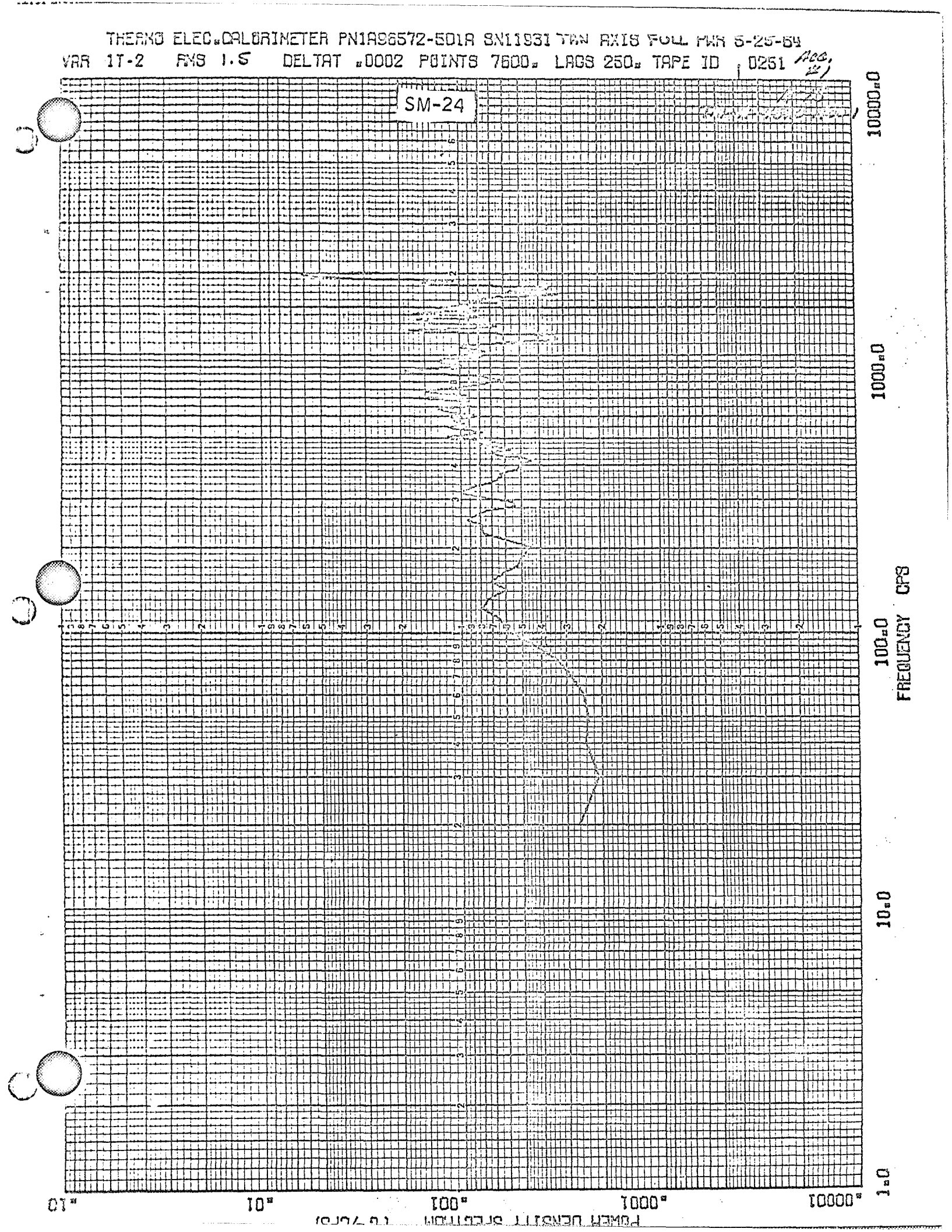
JOB NO 21475
SO 0251
2819-6011

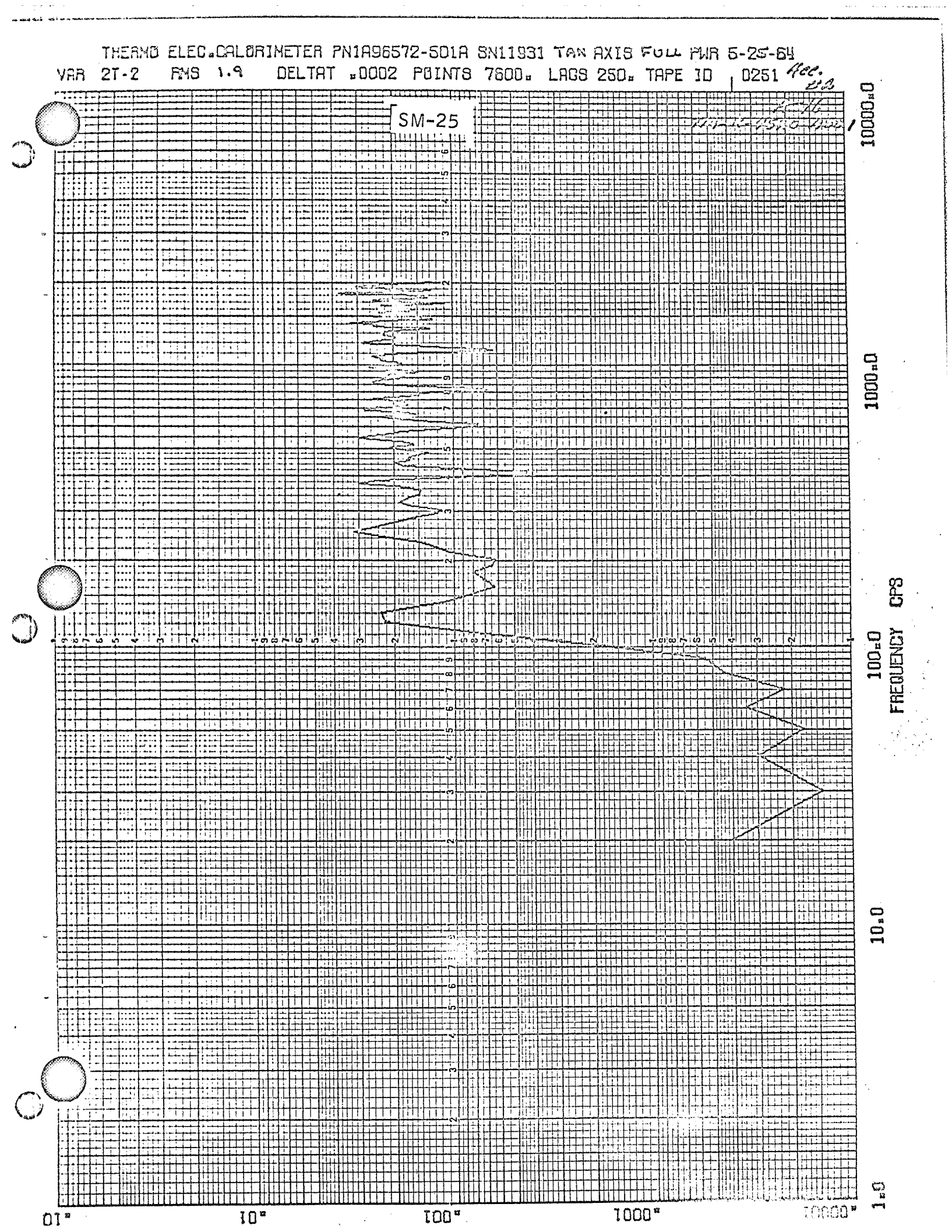


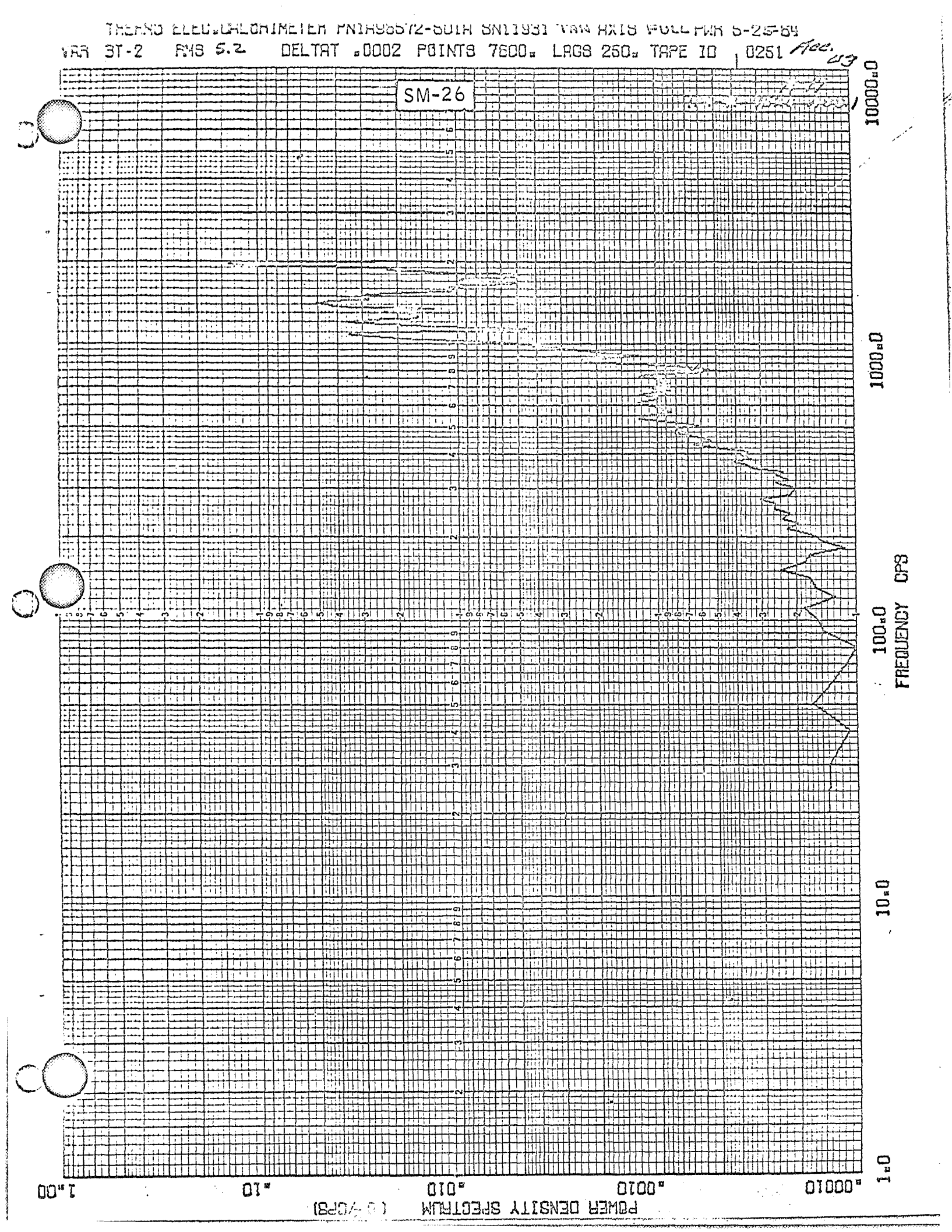
THERMO ELEC. CALORIMETER PN1A96572-501A SN11931 TAN AXIS FULL PWR 5-25-64

VAR 1T-2 RMS 1.5 DELTAT .0002 POINTS 7600. LAGS 250. TAPE ID 0251 Acc. #1

SM-24




THERMO ELEC. CALORIMETER PN1A96572-501A SN11931 TAN AXIS FULL PWR 5-25-64
VAR 2T-2 RMS 1.9 DELTAT .0002 POINTS 7600. LAGS 250. TAPE ID 0251
SM-25
10000.0
1000.0
100.0
10.0
1.0
FREQUENCY CPS
01"
10"
100"
1000"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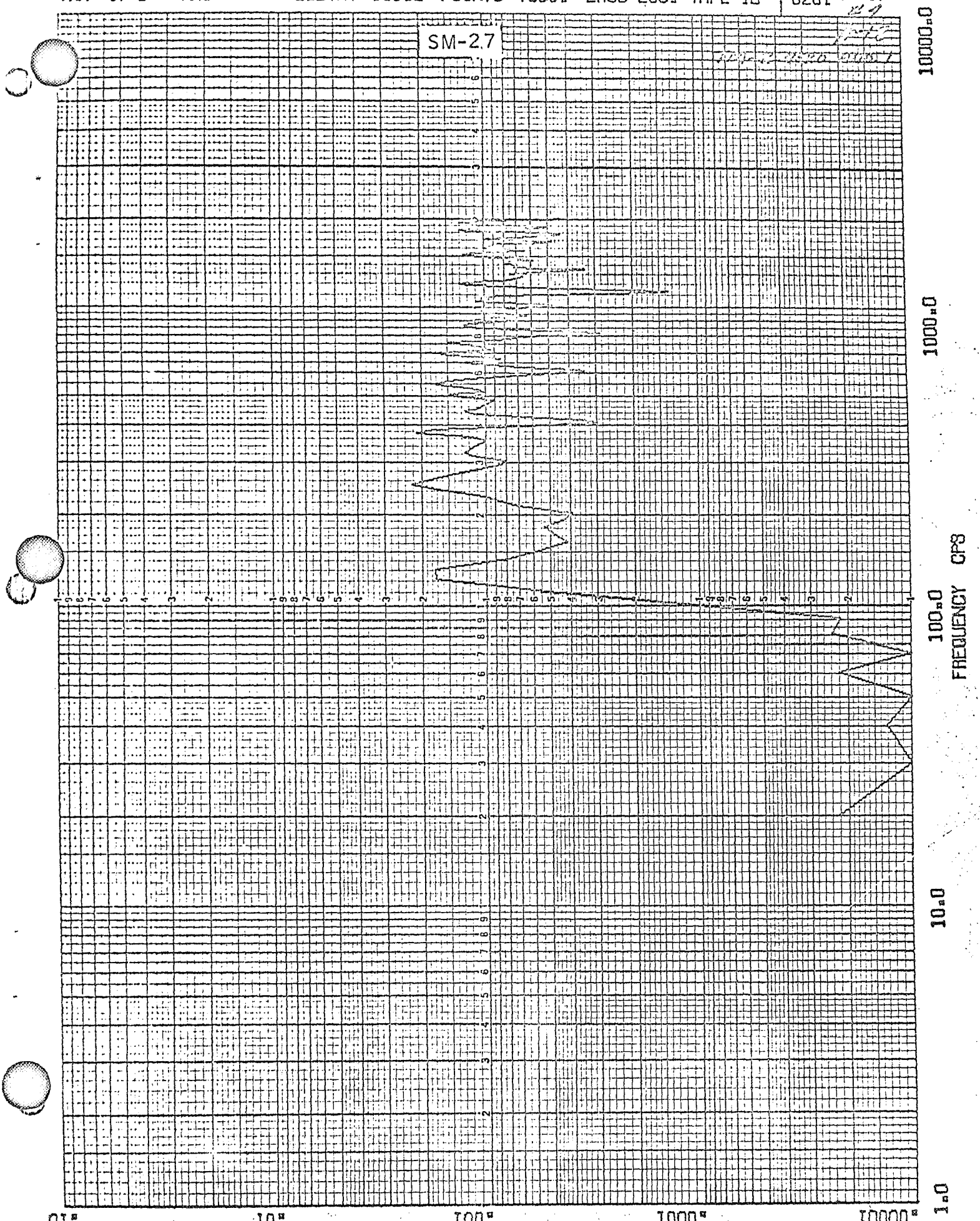
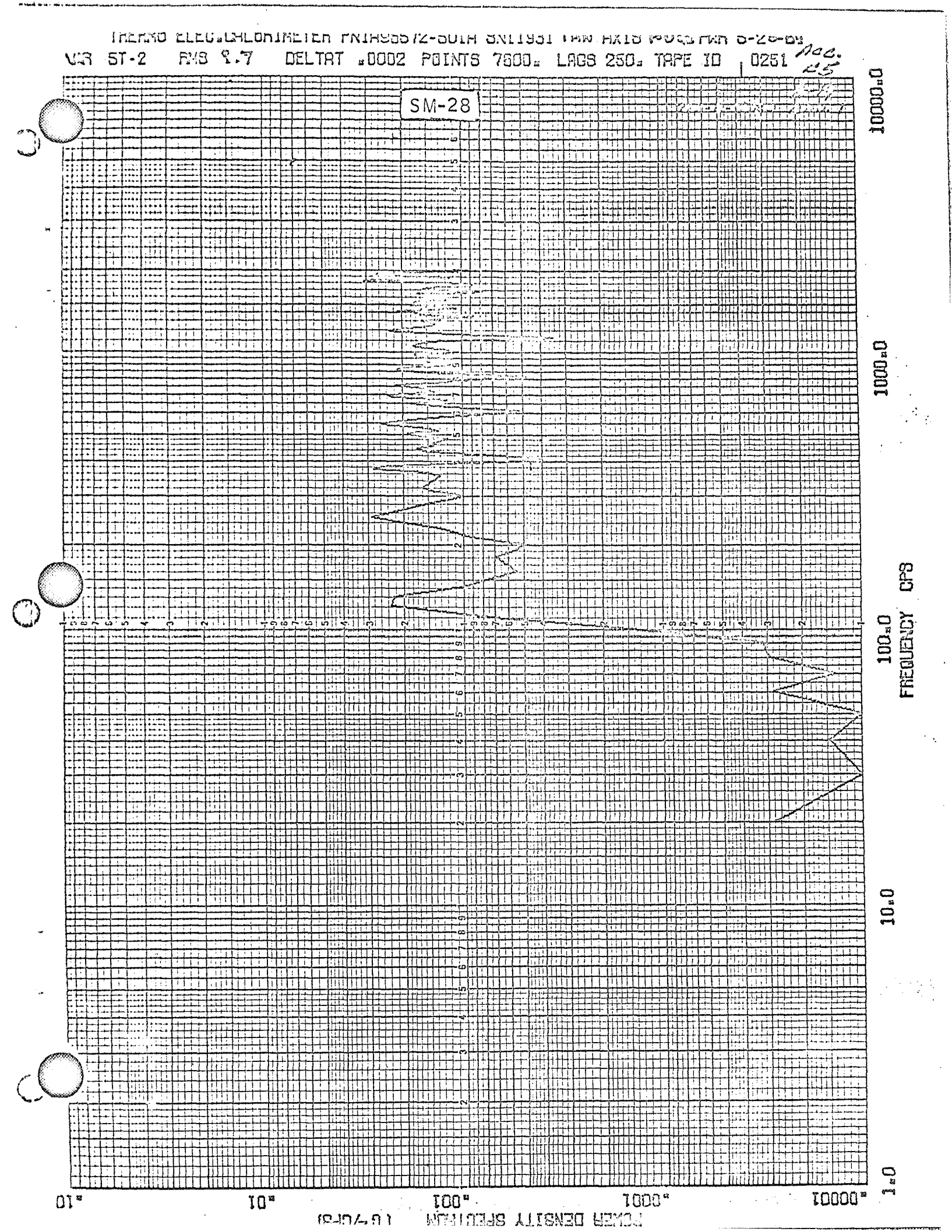
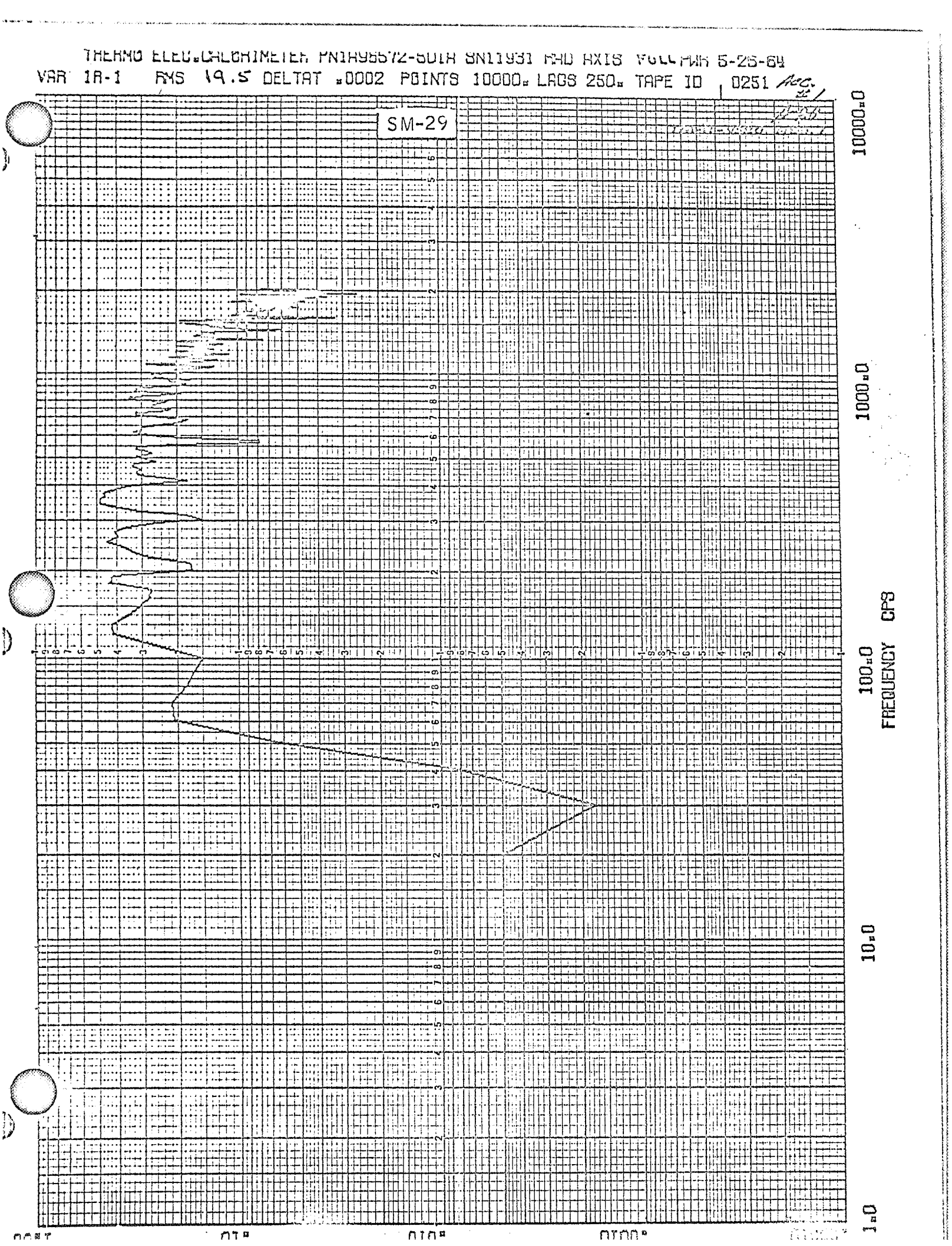
VAR 3T-2 RMS 5.2 DELTAT .0002 POINTS 7600. LAGS 250. TAPE ID 0251
SM-26
10000.0
1000.0
100.0
10.0
1.0
FREQUENCY CPS
.00010
.0010
.010
.10
1.00
POWER DENSITY SPECTRUM (G²/CPS)

THERMO ELEC. CALORIMETER PN1A98572-501A SN11931 TAN AXIS FULL PWR 5-25-64

VAR 4T-2 FAS 1.3 DELTAT .0002 POINTS 7600. LAGS 250. TAPE 10 , 0251 Rec. #9




THERMO ELEC. CHLORIMETER FNIH9557Z-SOUTH SN11931 TAN AXIS POS PWR 8-28-69
VER ST-2 RMS 9.7 DELTRT .0002 POINTS 7600. LAGS 250. TAPE ID 0251
SM-28
10000.0
1000.0
100.0
10.0
1.0
FREQUENCY CPS
.10
.01
.001
.0001
.00001
POWER DENSITY SPECTRUM (G²/CPS)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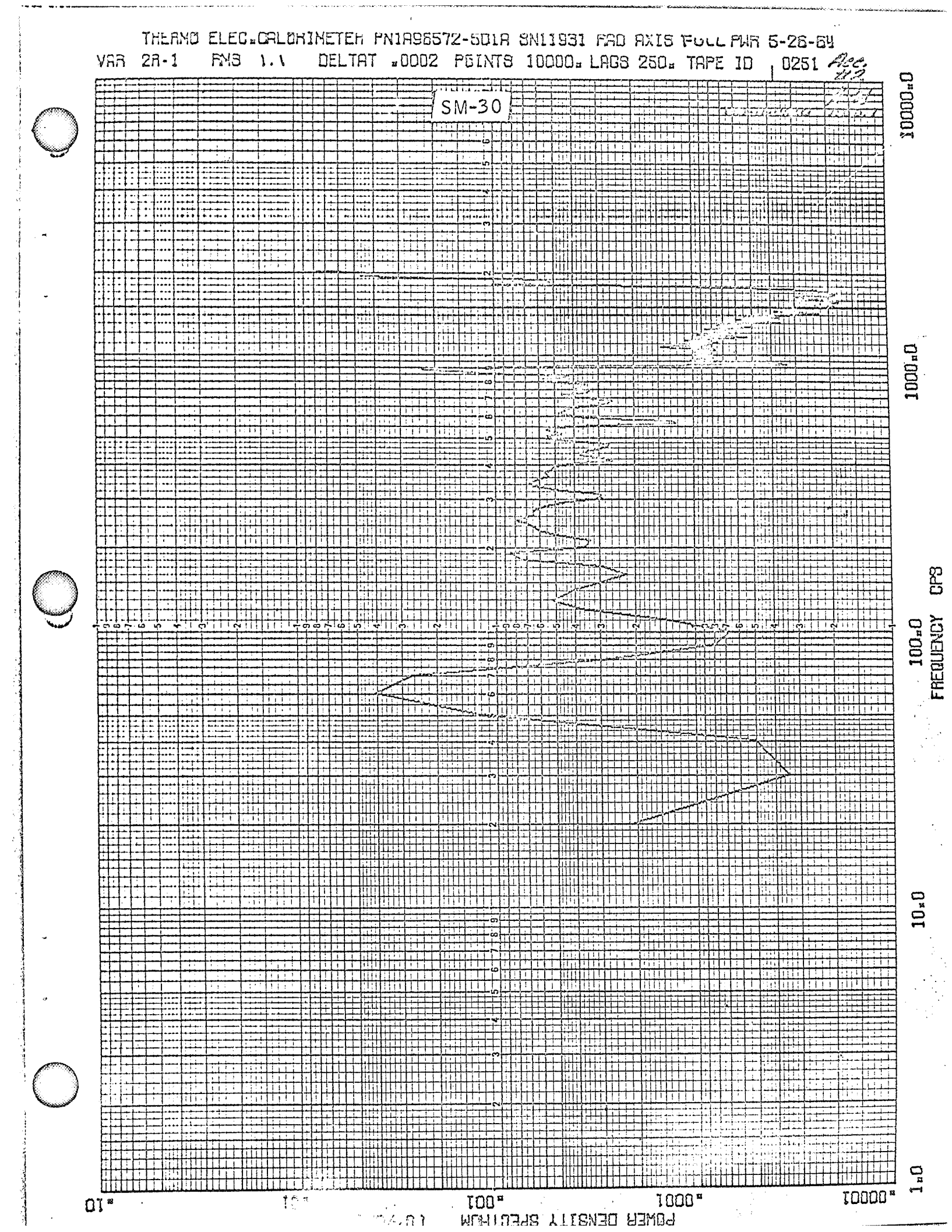
100.0
10.0
1.0
FREQUENCY CPS


THERMO ELEC. CALORIMETER PN1A96572-501A SN11931 RAD AXIS FULL PWR 5-26-64
VAR 2R-1 RMS 1.1 DELTAT .0002 POINTS 10000. LAGS 250. TAPE ID 0251
SM-30
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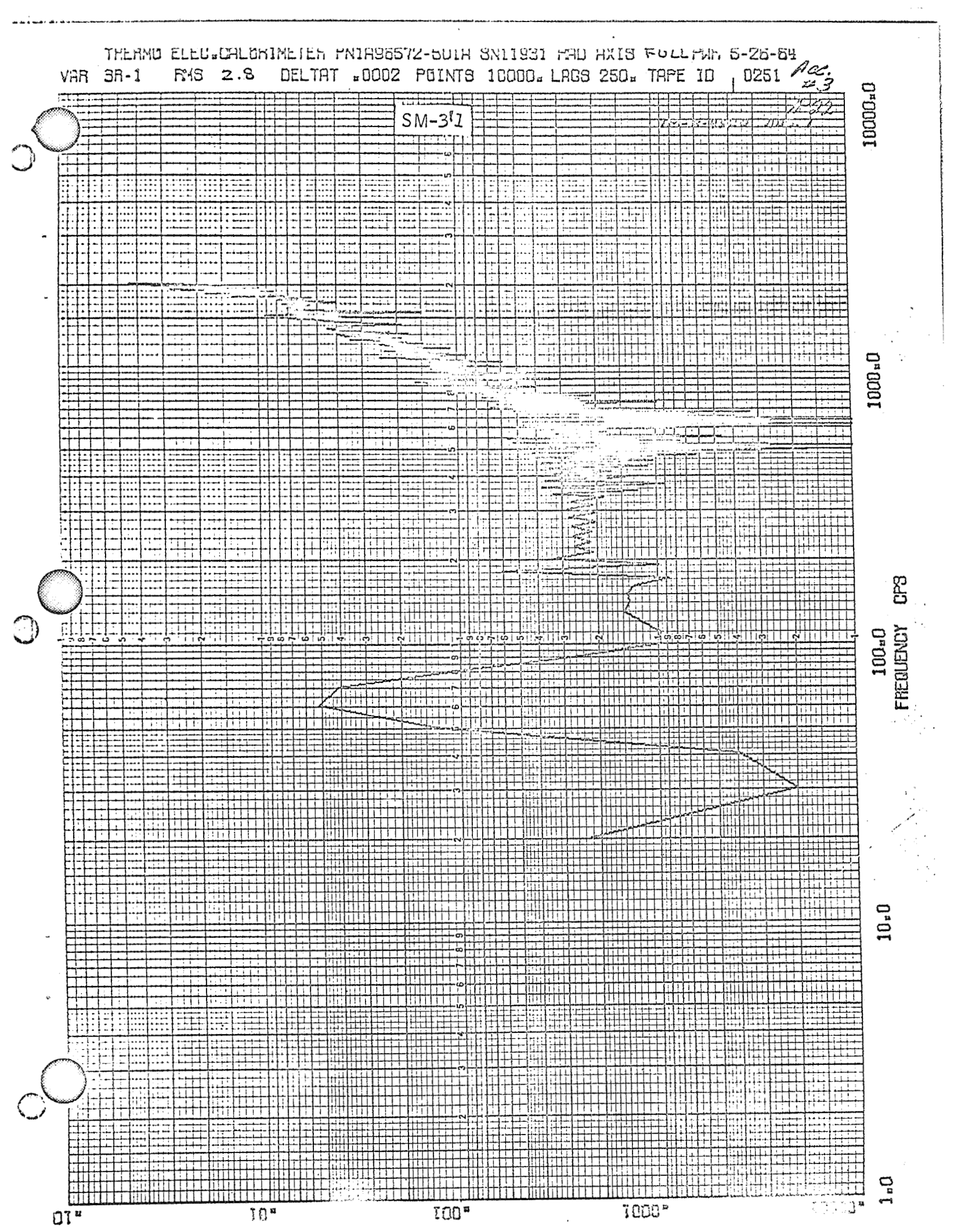
1000.0
100.0
10.0
1.0
FREQUENCY CPS
.01
.001
.0001
.00001
POWER DENSITY SPECTRUM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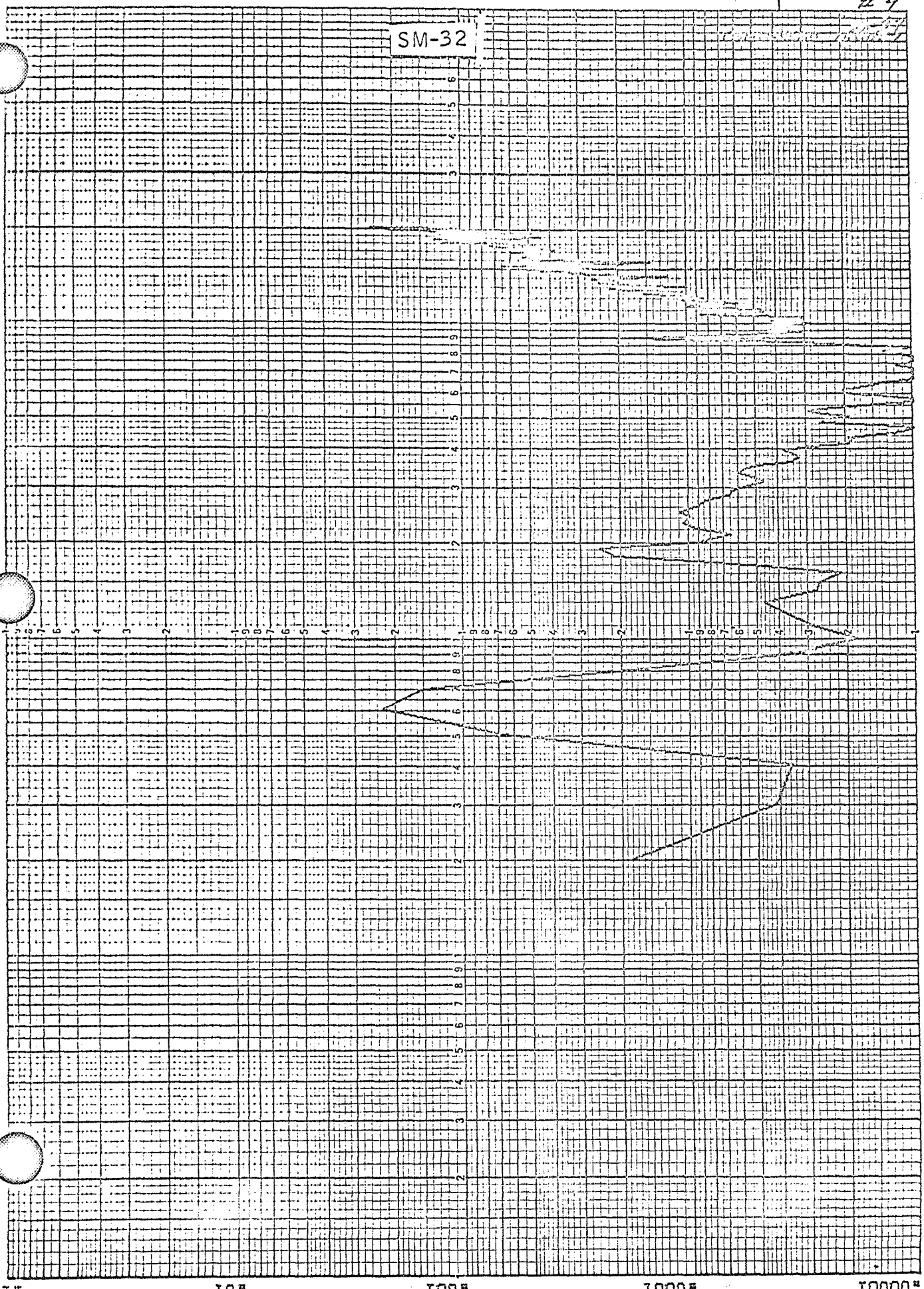
VAR 3R-1 RMS 2.8 DELTAT .0002 POINTS 10000. LAGS 250. TAPE ID 0251
SM-3 #1
10000.0
1000.0
100.0
10.0
1.0
FREQUENCY CPS
.01
.1
1.0
10.0
100.0
1000.0

THERMO ELEC. CALORIMETER PN1A5572-501A SN11931 RAD AXIS FULL PWR 5-26-64

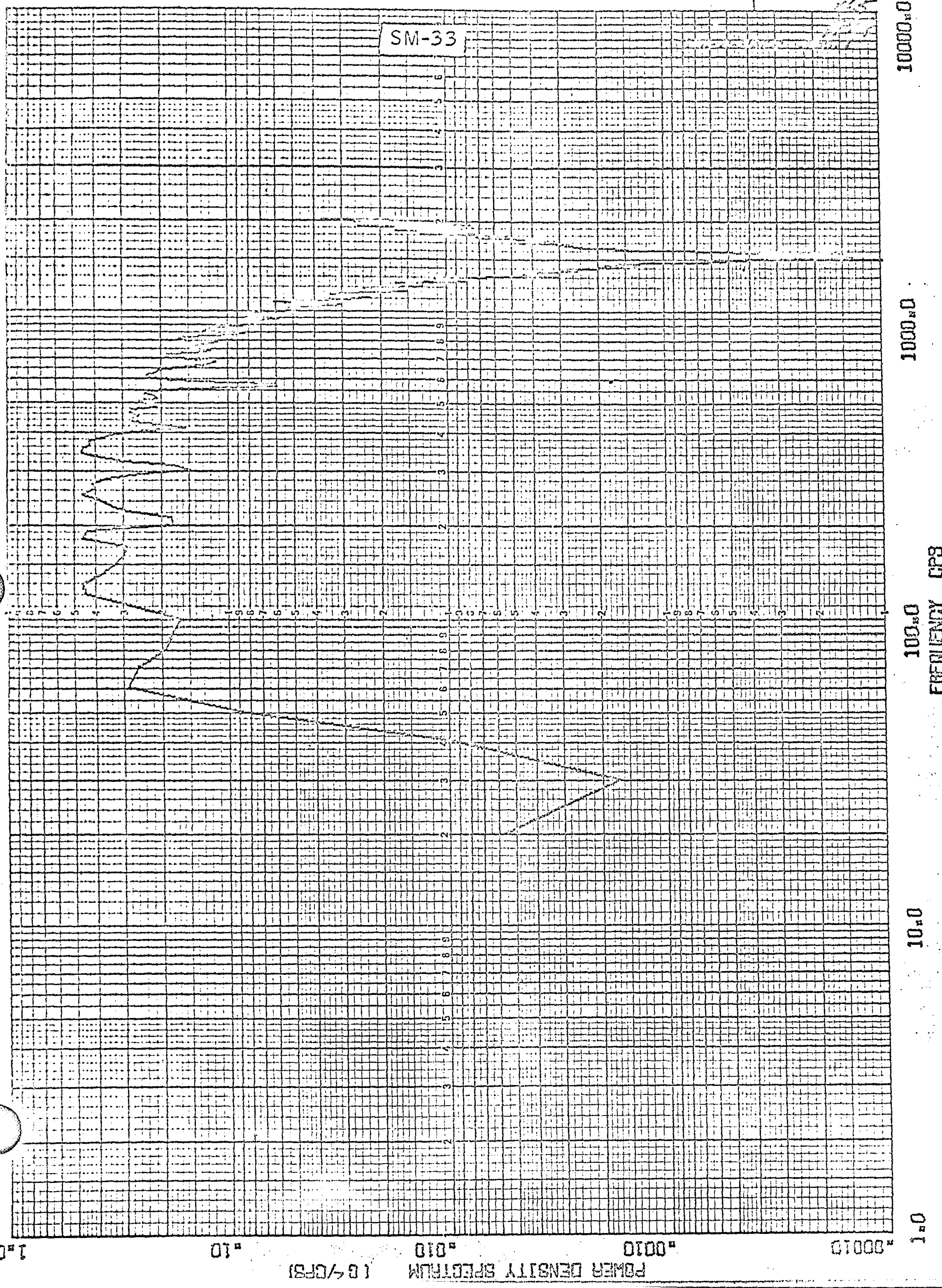
VBR 4R-1 RMS 0.7 DELTAT .0002 POINTS 10000. LAGS 250. TAPE ID 0251

SM-32

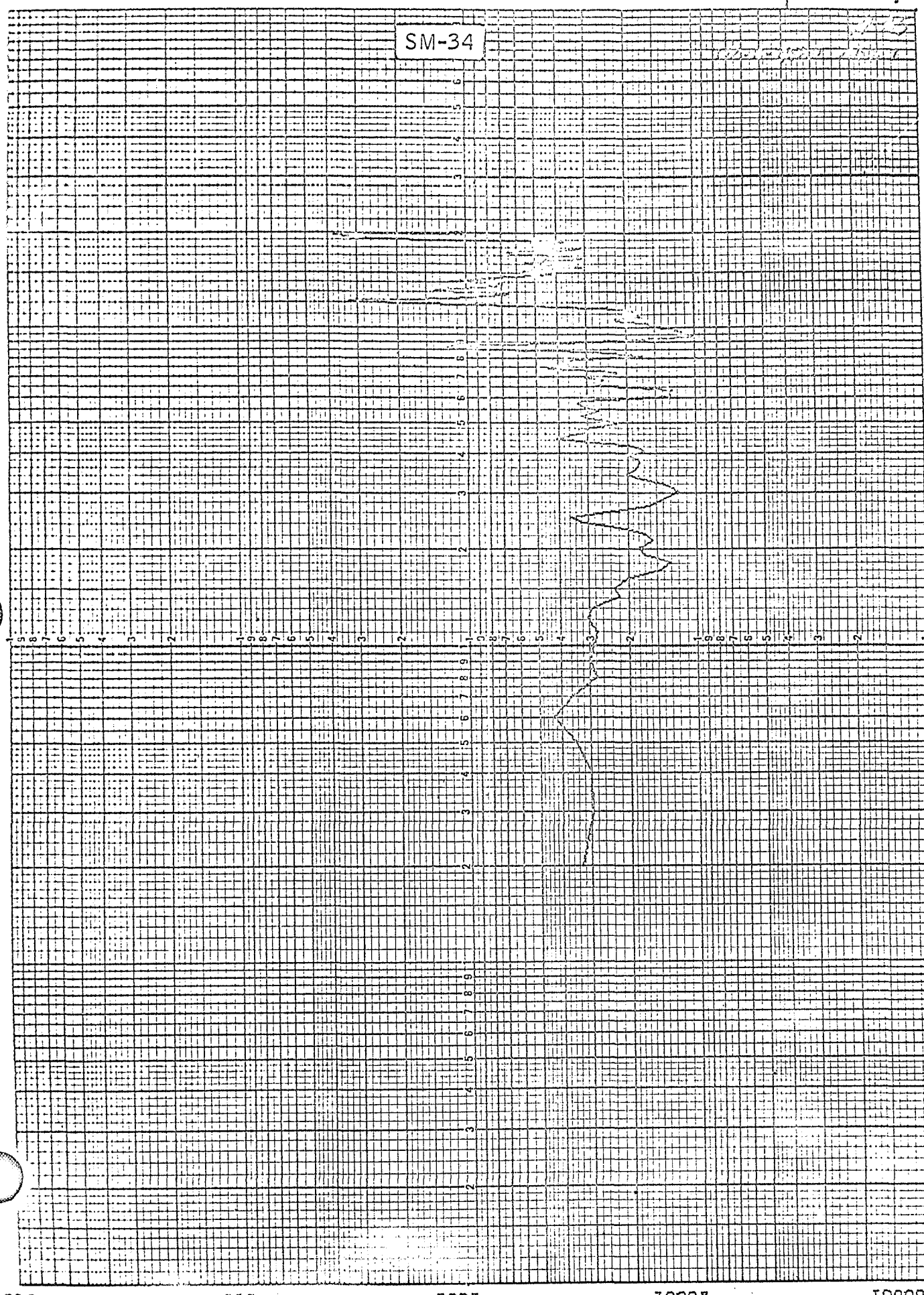


POWER DENSITY SPECTRUM (g²/c

THERMO ELEC.CALORIMETER PN1A35572-501A SN11931 RAD AXIS FULL PWR 5-23-65
VAR SA-1 RMS 14.8 DELTAT .0002 POINTS 10000. LAGS 250. TAPE ID 0251

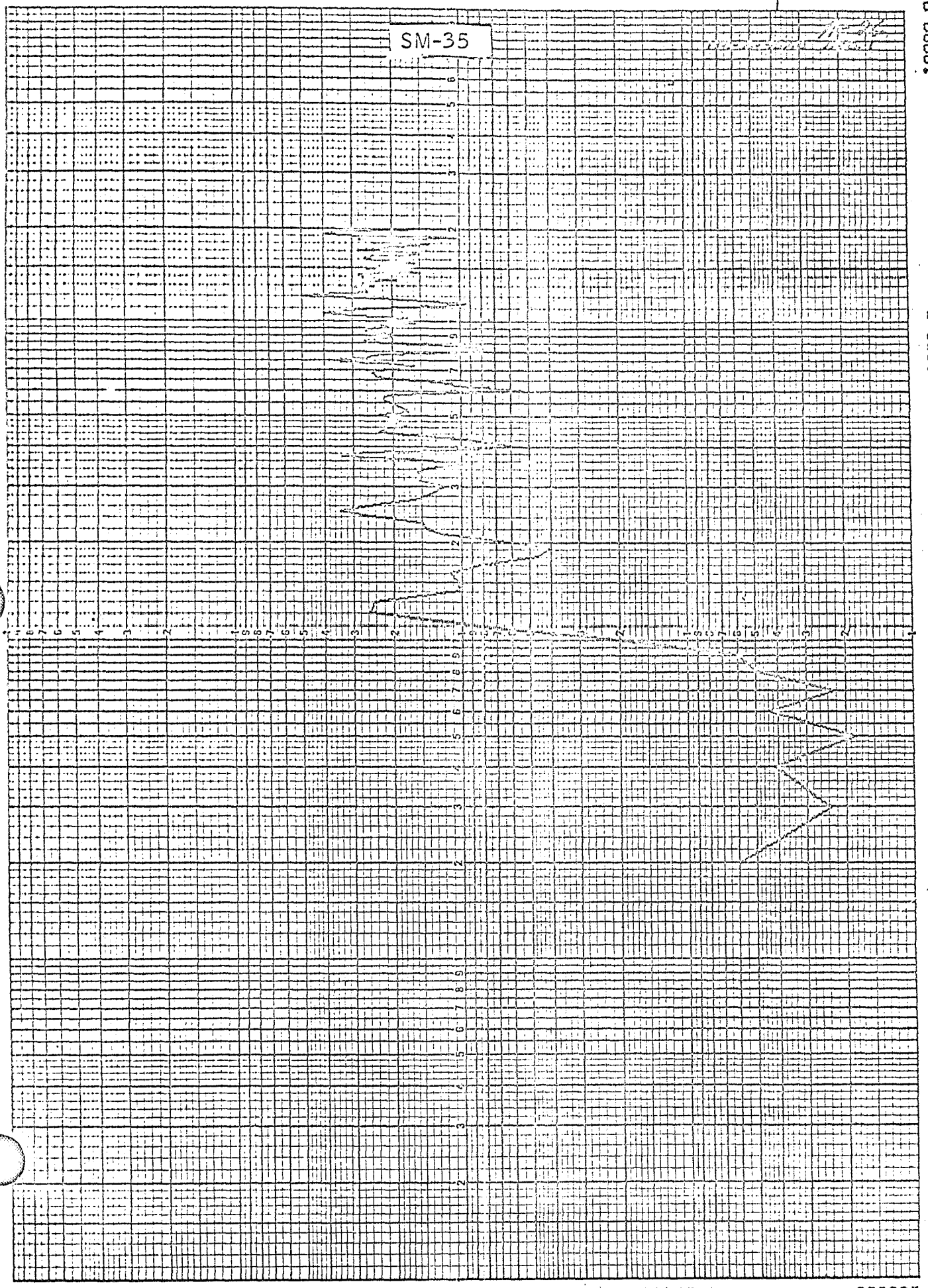


THERMO ELEC. CALORIMETER PN1A98572-501A SN11931 TWR AXIS FULL PWR 5-25-64 Accel
VAR 1TH-1 RMS 1.1 DELTAT .0002 POINTS 7600. LAGS 250. TAPE ID 0251 #1



THERMO ELEC. CALORIMETER PN1A96572-501H SN11931 TWR AXIS FULL PWR 6-25-84 Acc. #2

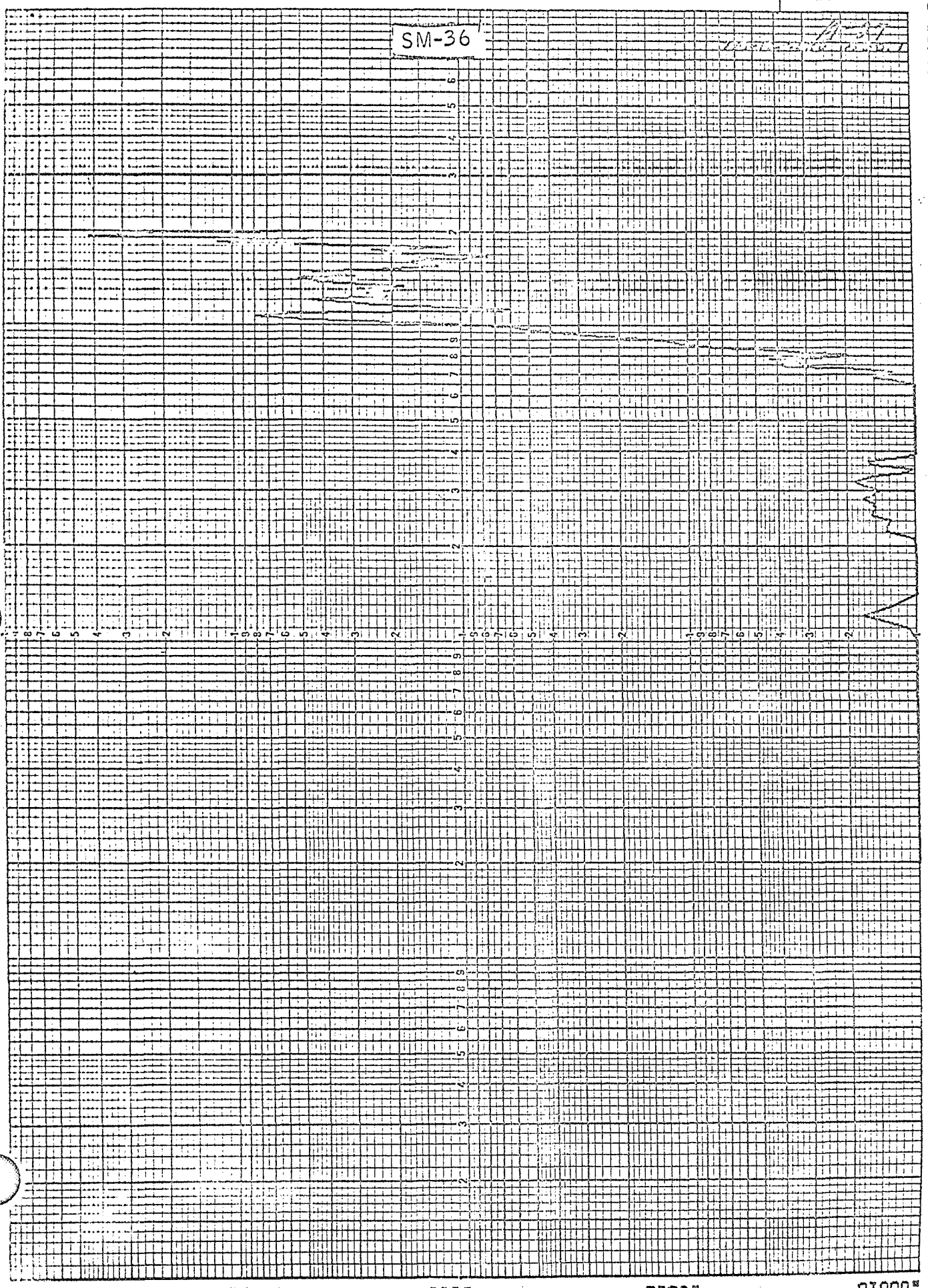
'RR 2TH-1 RMS 2.0 DELTAT .0002 POINTS 7600. LAGS 250. TAPE ID 0251



THERMO ELEC. CALORIMETER PN1AS6572-501A SN11931 THR AXIS VOLL PWR 5-25-64

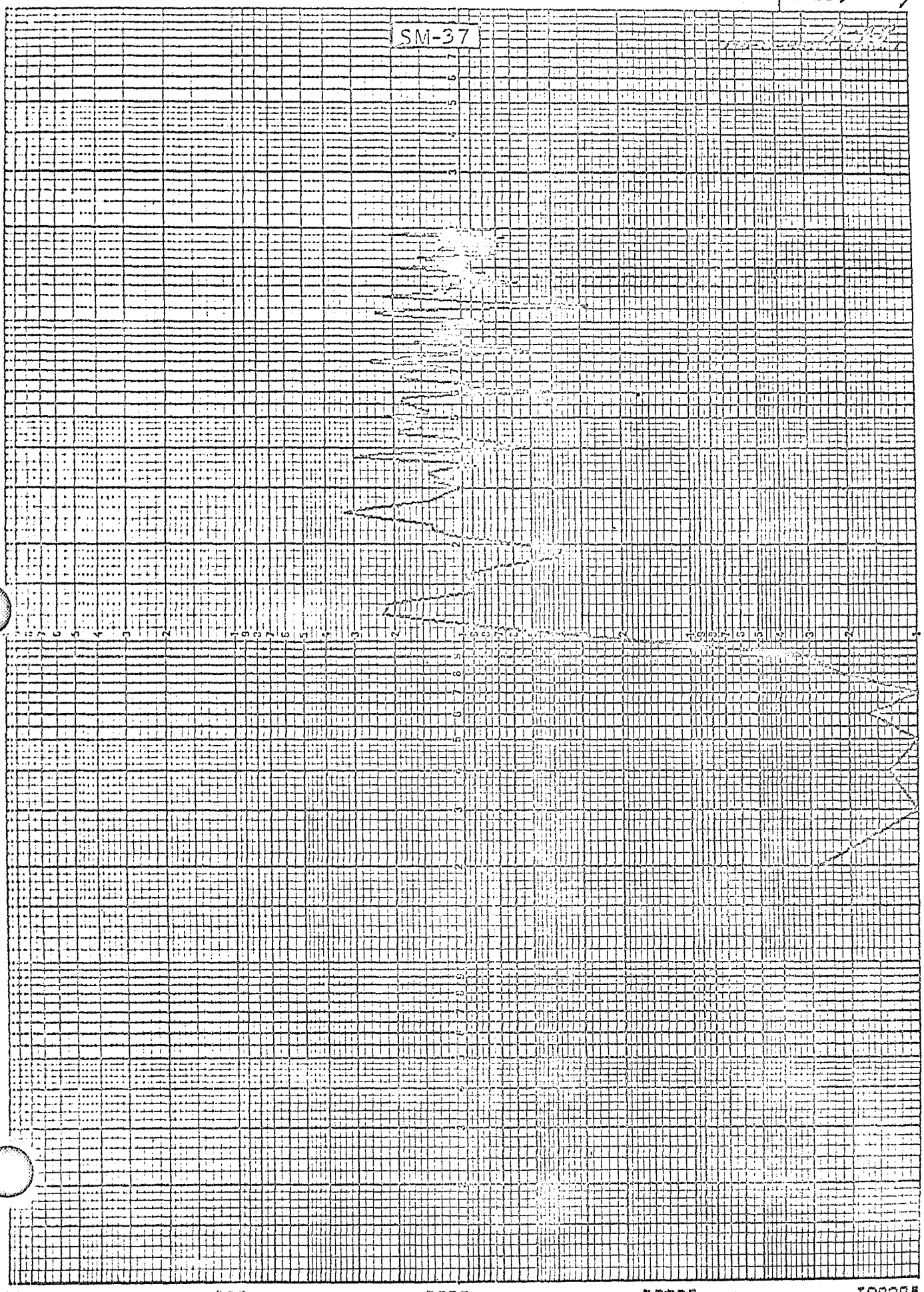
RR 3TH-1 AXS 7.Z DELTAT .0002 POINTS 7600. LABS 250. TAPE ID 0251 Acc. #3

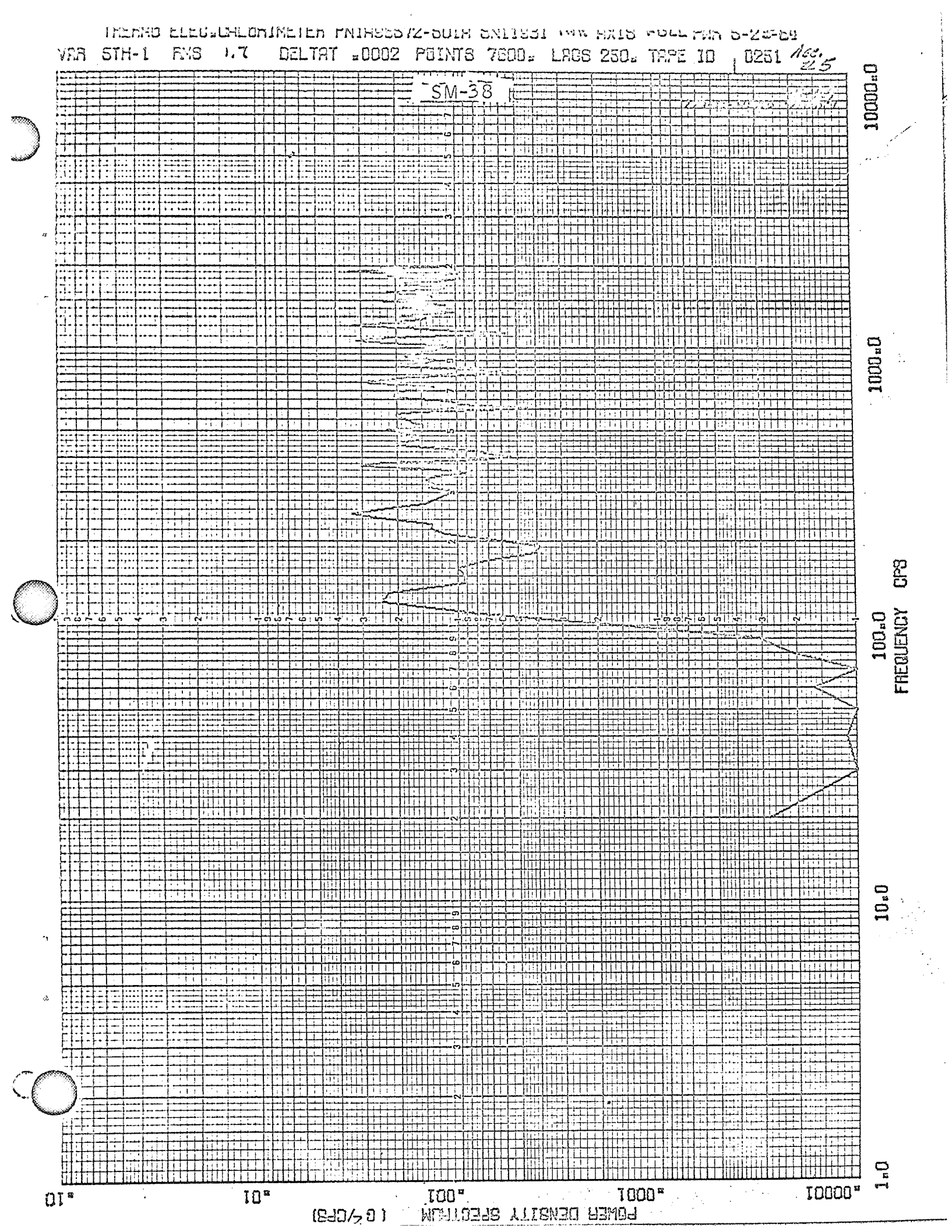
SM-36



THERMO ELEC.CALORIMETER PN1A53572-501A SN11581 TWR ANIS FULL PWR 5-25-84

VAR 4TH-1 AVG 1.5 DELTAT .0002 POINTS 7000. LAGS 250. TAPE ID 0251




SM-38
10000.0
1000.0
100.0
10.0
1.0
FREQUENCY CPS
.10
.01
.001
.0001
.00001
POWER DENSITY SPECTRUM (G²/CPS)

PREPARED BY R. Stolte

CHECKED BY

DATE: 5/27/64

DOUGLAS AIRCRAFT COMPANY, INC.

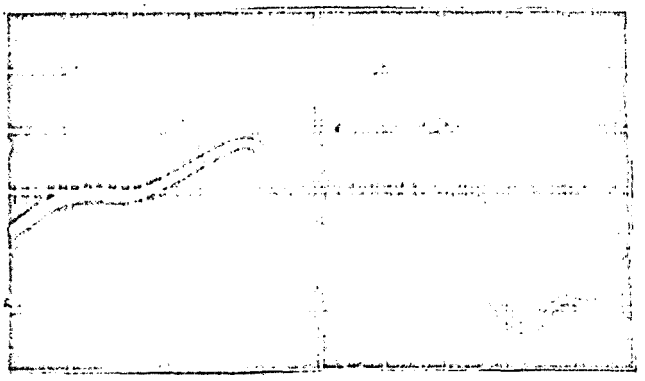
MISSILE AND SPACE SYSTEMS DIVISION

PAGE

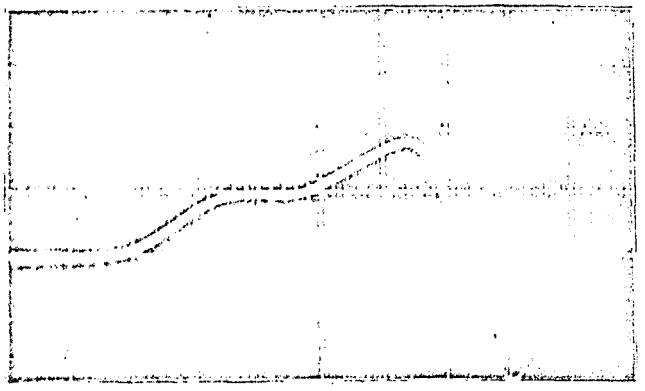
MODEL DSV - 4

TITLE THERMOELASTIC CALORIMETER Shock Test of Radial Axis

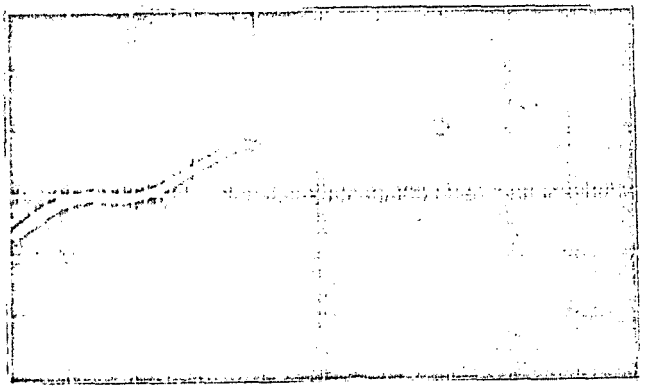
REPORT NO.:



Axis: Radial
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #1 in Radial axis



Axis Radial
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = 35 G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #2 in Radial Axis



Axis: Radial
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock Druation = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #3 in Radial Axis

PREPARED BY L. Stoltz

CHECKED BY

DATE: 5/27/54

DOUGLAS AIRCRAFT COMPANY, INC.

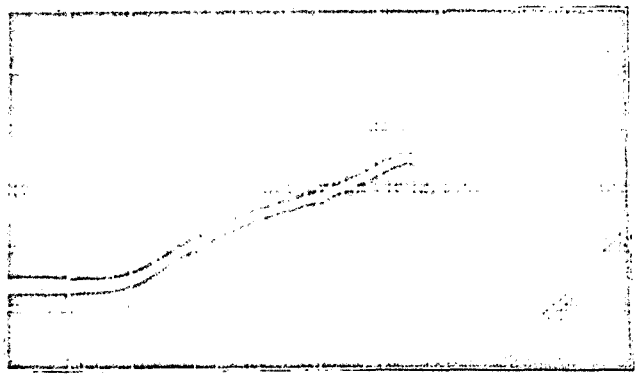
MISSILE AND SPACE SYSTEMS DIVISION

PAGE:

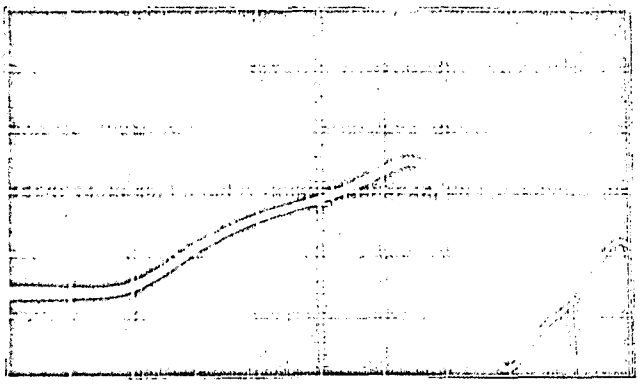
MODEL: DSV - 4

TITLE THERMOELECTRIC CALORIMETER Shock Test of Thrust Axis

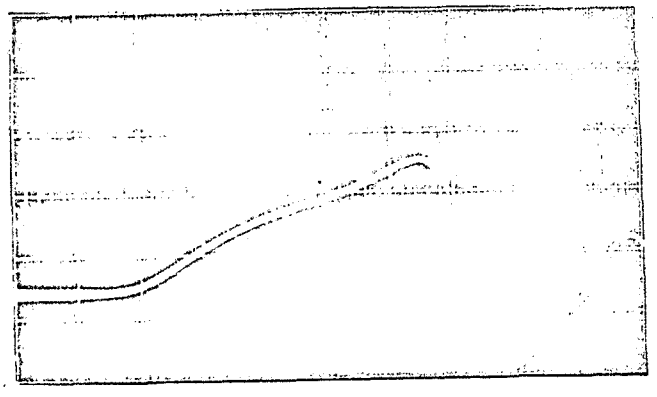
REPORT NO.:



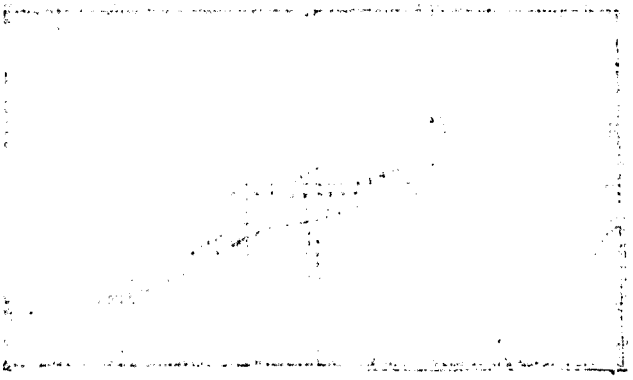
Axis: Thrust
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #1 Thrust Axis



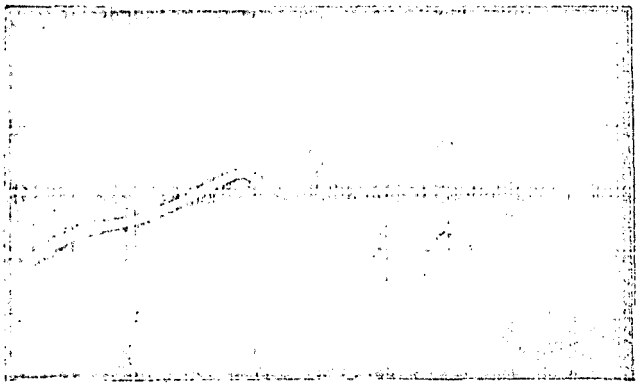
Axis: Thrust
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #2 Thrust Axis



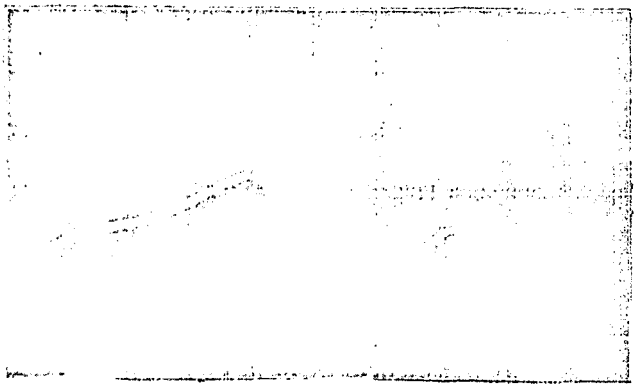
Axis: Thrust
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #3 Thrust Axis



Axis: Tangential
Vertical Sensitivity: 0.5 Volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #1 in tangential axis



Axis: Tangential
Vertical Sensitivity: 0.5 volts/cm.
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #2 in tangential axis



Axis: Tangential
Vertical Sensitivity: 0.5 volts/cm
Horizontal Sensitivity:
0.2 millisec/centimeter
millivolts = G's
Shock duration = 1 millisecond
Shock amplitude = G's
Accelerometer monitoring shock test was mounted on test fixture.
Shock #3 in tangential axis

TEST REPORT
FORM 37-113 (REV. 4-43)

DIVISION | LOCATION | SM-42

A-75

DATE 6/8/64 — CONSTANT HEAT FLUX OPER. TEST — SHEET 1 OF 2

SUBJECT Chromel Alumel Thermocouple and Thermo Electric Calorimeter — TM-R-4520 Rev. 1

TEST NO. — S. O. 5419-6011 — MODEL NO. DSV-4

OBJECT OF THIS DATA — EWO. 24475 — P/N 1A96572-501

JWO. 0251 — S/N 11931

OBSERVER R. Stoltz — WITNESS — AGENCY

Time (min.)	Thermocouple (mv Output)		Thermocouple (deg. F)		Thermo Elec. Calorimeter (mv Output)			
0.03	1.0		77.0		12.8			
0.2	1.1		81.5		13.8			
0.4	1.3		90.5		13.8			
0.6	1.6		103.7		13.8			
0.8	1.9		117.0		13.8			
1.0	2.3		134.7		13.7			
1.2	2.7		151.5		13.6			
1.4	3.0		164.7		13.5			
1.6	3.4		182.0		13.4			
1.8	3.6		190.5		13.2			
2.0	4.0		207.7		13.1			
2.2	3.7		195.0		13.0			
2.4	3.7		195.0		12.9			
2.6	3.8		199.0		12.8			
2.8	3.9		203.7		12.7			
3.0	4.0		207.7		12.6			
3.2	4.0		207.7		12.5			
3.4	4.1		212.0		12.4			
3.6	4.2		216.5		12.3			
3.8	4.2		216.5		12.2			
4.0	4.1		212.0		12.1			
4.2	4.0		207.7		12.0			
4.4	4.0		207.7		12.0			
4.6	4.0		207.7		11.8			
4.8	4.0		207.7		11.8			
5.0	4.0		207.7		11.7			
5.2	4.0		207.7		11.6			
5.4	4.0		207.7		11.5			
5.6	4.0		207.7		11.4			
5.8	4.0		207.7		11.4			
6.0	4.0		207.7		11.3			
6.2	4.0		207.7		11.2			

TEST REPORT
FORM 37-113 (REV. 4-43)

DIVISION | LOCATION | SM-43

A-76

DATE 6/8/64 — CONSTANT HEAT FLUX OPER. TEST — SHEET 2 OF 2

SUBJECT Chromel Alumel Thermocouple and Thermo Electric Calorimeter — TR-B-4586 ADD. 1

TEST NO. — S. O. 5419-6011 — MODEL NO. DSV-4

OBJECT OF THIS DATA — M.O. 21475 — P/N 1A96572-501

M.O. 0251 — S/N 11931

OBSERVER — WITNESS — AGENCY

Time (min.)	Thermocouple (mv Output)		Thermocouple (deg. F)		Thermo Elec. Calorimeter (mv Output)			
6.4	4.0		207.7		11.2			
6.6	4.0		207.7		11.1			
6.8	3.9		203.7		11.0			
7.0	3.9		203.7		11.0			
7.2	3.9		203.7		10.9			
7.4	4.0		207.7		10.8			
7.6	4.0		207.7		10.8			
7.8	4.0		207.7		10.8			
8.0	4.0		207.7		10.7			

Note: At time equal to zero the Calorimeter output is equal to zero.

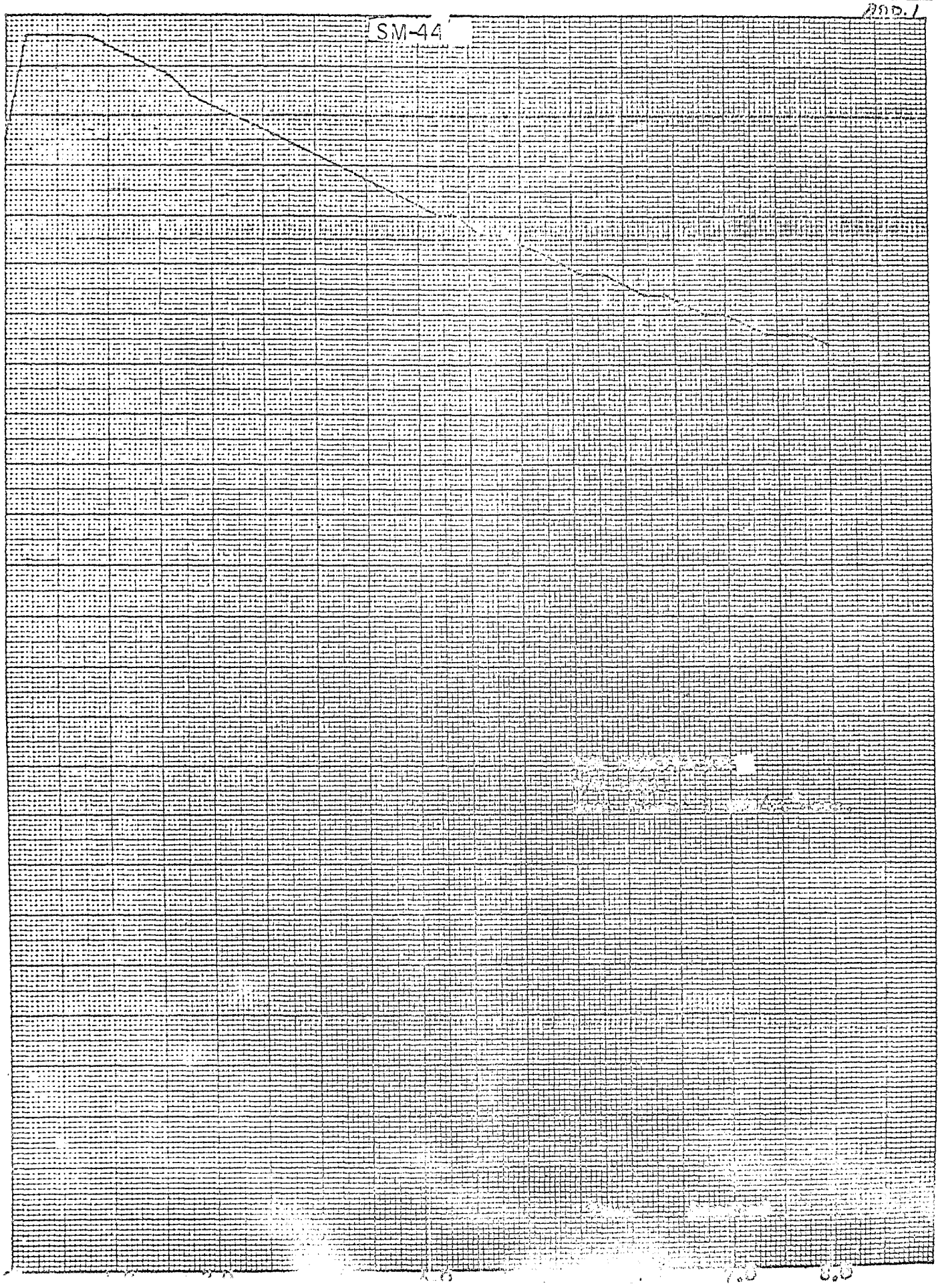
A chromel-alumel thermocouple has an output of approximately .023 mv/°F.

FORM 23-BP (REV. 2-64)

PREPARED BY: R. Stoltz
CHECKED BY:
DATE: 6/8/64
TITLE: Thermo Electric Calorimeter Output Curve

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE AND SPACE SYSTEMS DIVISION

PAGE: 11-11
MODEL: DSV-4
REPORT NO.: TM-B-4520
Bnd. 1



FORM 23-67
(REV. 3-64)

PREPARED BY: R. Stoltz
CHECKED BY:
DATE: 6/8/64

DOUGLAS AIRCRAFT COMPANY, INC.
MISSLE AND SPACE SYSTEMS DIVISION

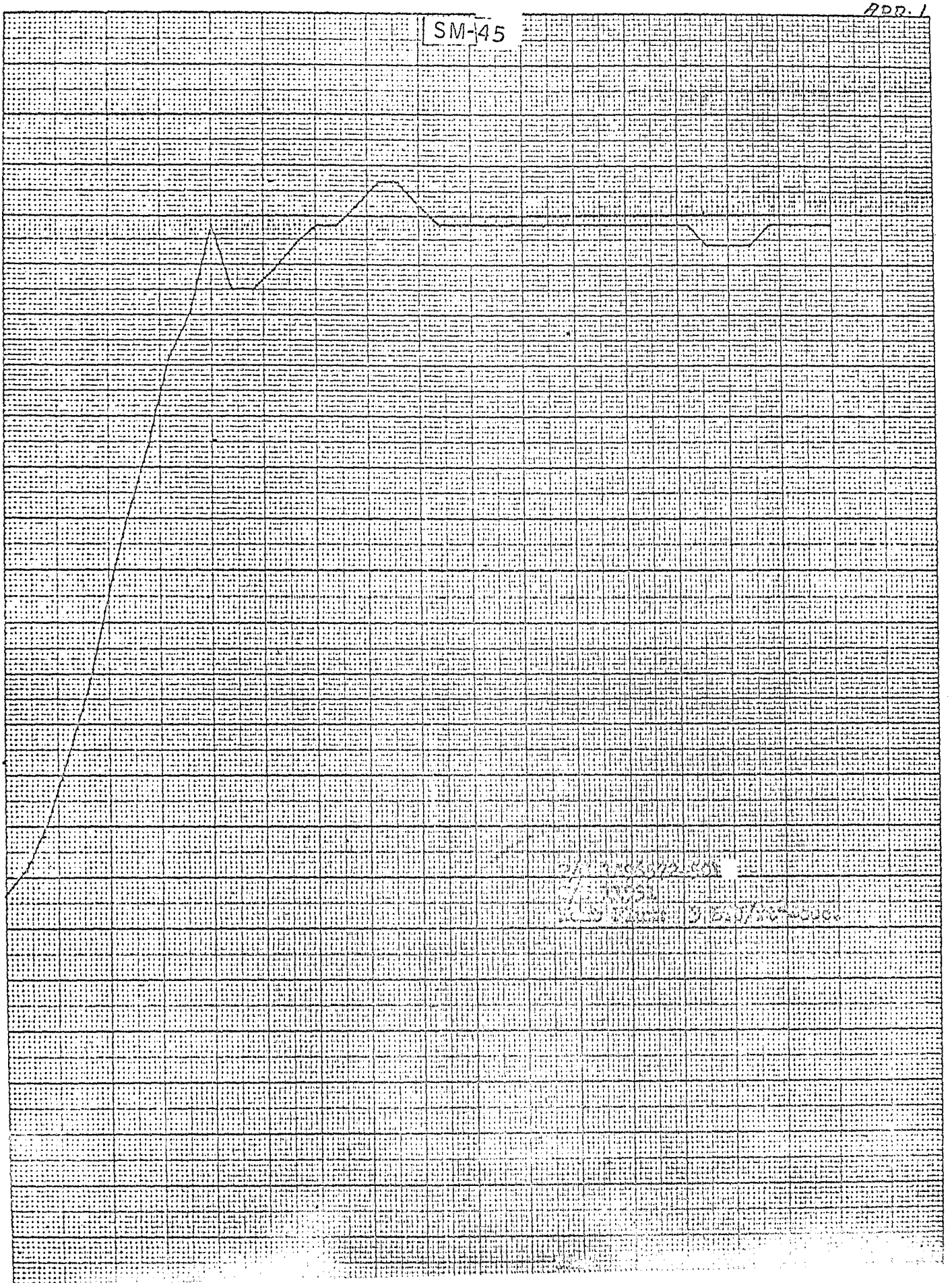
PAGE: A-78
MODEL: DSV-4
REPORT NO.: TM-R-4520 ADD. 1

TITLE: Chromel-Alumel Thermocouple (Heat Sink Temperature

SM-45

220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

(deg. F - Omit)



TEST REPORT
FORM 37-113 (REV. 4-63)

DIVISION | LOCATION | SM-46

A-79

6/8/64 OPER. PERIOD HEAT FLUX TEST SHEET 1 OF 2

SUBJECT Chromel Alumel Thermocouple and Thermo Electric Calorimeter TM-B-4520 Rev. 1

TEST NO. S. O. 5419-6011 MODEL NO. DSV-4

OBJECT OF THIS DATA EWO. 21475 P/N 1496572-501

JWO. 0251 S/N 11936

OBSERVER R. Stoltz WITNESS AGENCY

Time (min.)	Thermocouple (mv Output)		Thermocouple (deg. F)		Thermo Elec. Calorimeter (mv Output)			
0.03	0.8		68.0		13.7			
0.2	0.8		68.0		13.6			
0.4	1.1		81.5		13.6			
0.6	1.4		95.0		13.5			
0.8	1.8		112.5		13.4			
1.0	2.1		125.5		13.2			
1.2	2.5		143.0		13.2			
1.4	2.8		156.0		13.0			
1.6	3.2		173.3		12.8			
1.8	3.5		186.3		12.7			
2.0	3.8		199.0		12.5			
2.2	4.0		207.7		12.4			
2.4	4.0		207.7		12.2			
2.6	4.1		212.0		12.1			
2.8	4.0		207.7		12.0			
3.0	4.1		212.0		12.0			
3.2	4.2		216.5		11.9			
3.4	4.2		216.5		11.8			
3.6	4.3		220.7		11.7			
3.8	4.4		225.0		11.6			
4.0	4.4		225.0		11.6			
4.2	4.4		225.0		11.5			
4.4	4.4		225.0		11.4			
4.6	4.6		233.7		11.3			
4.8	4.6		233.7		11.2			
5.0	4.7		238.0		11.1			
5.2	4.7		238.0		11.1			
5.4	4.7		238.0		11.0			
5.6	4.6		233.7		10.9			
5.8	4.7		238.0		10.8			
6.0	4.7		238.0		10.7			
6.2	4.7		238.0		10.6			

TEST REPORT
FORM 37-113 (REV. 4-43)

DIVISION | LOCATION | SM-47

A-80

6/8/61
OPER PERIOD HEAT FLUX
SUBJECT Chromel Alumel Thermocouple and Thermo Electric Calorimeter TEST
SHEET 2 OF 2
TM-R-4580 RED.1

TEST NO. S. O. 5419-6011 MODEL NO. DSV-4
OBJECT OF THIS DATA ENO. 24475 P/N 1A96572-501
JNO. 0251 S/N 11936
OBSERVER R. Stoltz WITNESS AGENCY

Time (min.)	Thermocouple (mv Output)		Thermocouple (deg. F)		Thermo Elec. Calorimeter (mv Output)			
6.4	4.8		242.5		10.6			
6.6	4.8		242.5		10.5			
6.8	4.8		242.5		10.4			
7.0	4.8		242.5		10.4			
7.2	4.8		242.5		10.3			
7.4	4.8		242.5		10.2			
7.6	4.8		242.5		10.2			
7.8	5.0		251.5		10.1			
8.0	4.9		247.0		10.0			

Note: At time equal to zero the Calorimeter output is zero.

A chromel-alumel thermocouple has approximately 0.023 mv./°F.

FORM 21-3P
(REV 3-64)

PREPARED BY: R. Stoltz

CHECKED BY:

DATE: 6/8/64

TITLE: Chromel-Alumel Thermocouple (Heat Sink Temperature)

DOUGLAS AIRCRAFT COMPANY, INC.

MISSILE AND SPACE SYSTEMS DIVISION

PAGE:

MODEL: DSV-4

REPORT NO.

REPORT NO.

SM-49

240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

(deg. Fahrenheit)

KEUFFEL & ESSER CO. LA 0701

PREPARED BY: R. Stoltz
CHECKED BY:
DATE: 6/8/64

DOUGLAS AIRCRAFT COMPANY, INC.
MISSILE AND SPACE SYSTEMS DIVISION

PAGE: A-81
MODEL: DSV-4
REPORT NO.: TM-R-4586
APP. I

TITLE: Thermo Electric Calorimeter Output Curve